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## NOTES ON THE ENDOPHYTIC PROTOZOA

WITH A LIST OF SOME CANADIAN HOST PLANTS, AND AN ACCOUNT  
OF FOUR APPARENTLY NEW FORMS

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The first record of the presence of a protozoon in the latex of plants was made by Lafont (1909). The manner of the discovery is told by França (1920) from a personal letter written to him by Lafont. The latter, while working in Mauritius, was struck by the abundance of starch grains in certain latices, and concluding that these latices should make an excellent culture medium, instructed his assistant, David, to examine the latex of certain Euphorbias for motile bodies. David found a flagellate in *Euphorbia pilulifera* which Lafont named *Leptomonas davidi*. Two years later Lafont (1911) announced that a hemipteron *Nyssius euphorbiae* was responsible for the transmission of the parasite.

*L. davidi* has since been recorded from several countries, and there have been various contributions to our knowledge of its morphology, hosts and method of transmission. Other workers have shown that the Euphorbias are not unique, but that several other latex-bearing plants serve as hosts to flagellates and amoebae. Such parasites have been recorded from several species of the Euphorbiaceae, and from members of the Asclepiadaceae, Apocynaceae, Urticaceae, Artocarpaceae, Sapotaceae and Compositae. The work of Franchini, who during the past three years has published a long series of papers on the subject, should be specially mentioned.

Since most of the recorded host plants were tropical or subtropical, the writer undertook a survey of the latex-bearing plants in his vicinity to learn whether our northern plants also serve as hosts to the endophytic protozoa. It was found that these organisms occur quite commonly in such plants near Montreal.

The plants listed below were found to be indubitably infected. In some of them the organisms were very abundant and appeared on

almost every slide examined. In others they were rare, and a few organisms were found only after a prolonged search.

With the exception of the lettuce, and probably *Asclepias syriaca*, the species here listed are recorded for the first time as hosts of endophytic protozoa.\*

Moraceae	<i>Morus alba</i>
Papaveraceae	<i>Chelidonium majus</i>
Convolvulaceae	<i>Convolvulus sepium</i>
Apocynaceae	<i>Apocynum androsaemifolium</i>
Asclepiaceae	<i>Asclepias syriaca</i>
Euphorbiaceae	<i>Euphorbia helioscopia</i>
Compositae	<i>Hieracium aurantiacum</i> , <i>Lactuca sativa</i> <i>L. canadensis</i> , <i>Sonchus arvensis</i> <i>S. oleraceus</i> , <i>Taraxacum officinale</i> <i>Lapsana communis</i> , <i>Tragopogon arvensis</i>

A study of the various organisms is in progress; a brief account of four forms as they appear in preparations of the latex is given here.

#### A PARASITE OF THE LATEX OF *Asclepias syriaca* L. (Plate I)

*Asclepias syriaca* is a common weed growing in waste places. Examination of the latex with which it is abundantly supplied, showed the presence of organisms varying in size and shape, typically elongate but sometimes oval, spherical or irregular. Preparations from some plants showed numerous organisms, others very few, but in no case where a careful re-examination was made did I find any plants quite free from the parasite. There was no noticeable injury to the host. Some plants showed signs of general unthriftness, but this was probably due to other causes as neighboring plants, equally heavily infected, were strong, robust and healthy. The parasites were found in the latex of the leaves, stem, roots and young fruit, and in the seeds. In many cases the young fruit was particularly rich in all types of the parasite, but especially in leishmaniform bodies. The non-flagellate stages must be either extremely sluggish or non-motile. They could be seen in the fresh latex but no movement was detected.

The protoplasm is usually granular, sometimes slightly vesicular. Either the periplast is occasionally irregularly thickened or folded, or else there are inclusions near it which give this impression. More or less numerous dark colored granules are sometimes included in the protoplasm. The nucleus is of moderate size, dense, homogeneous and deeply staining. It is usually surrounded by a lightly stained area in which a small body, probably a centrosome, can sometimes be detected. The position of the nucleus varies, sometimes it is placed in the center, sometimes at one side and sometimes near one end of the organism.

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\* Organisms were found in the latex of the fig and certain other exotic plants growing in the college greenhouses.

The majority of the elongate forms range from 5 to  $8\mu$  in length by 2 to  $4\mu$  in greatest breadth, but larger or smaller forms are often found. The largest individual found was 21 by  $4\mu$  and was obtained from the latex of a very young seedling. The extremities may be both pointed, both blunt, or one may be blunt and the other pointed. The organism is sometimes symmetrical about the long axis, sometimes with a greater convexity on one side, resulting occasionally in an almost hemispherical form. An occasional crescent-shaped individual is also found. Often a short sinus near one end gives the organism the appearance of having a beaked head. These elongated forms usually have one trophonucleus although two or more may be present. In some individuals there is a punctiform body, possibly a blepharoplast near one extremity; in others a similar body is found nearer the nucleus. In very rare cases a rudimentary flagellum has been observed (Plate I a).

The spherical and oval bodies vary from about 2 to  $5\mu$  in diameter. In some cases there is a single nucleus; in others are found the typical leishmaniform bodies with trophonucleus and blepharoplast. Dividing forms are often seen among the spherical bodies, but more rarely among the elongate ones. Here the division appears to be often irregular, in some instances almost transverse instead of conforming to the typical longitudinal method of the leptomonads.

The aerial stems of the host plant die on the approach of winter, and the following year new shoots come up from the perennial root stocks. The parasites have been found in the overwintering roots, and the first shoots from these roots in the spring are often teeming with them. The small round bodies pass into the seed where they remain inactive and infect the new plants the following year. Seeds gathered in the autumn or winter, after the first snow, will germinate readily. From such seeds I obtained at five different times during winter and spring, seedlings which were rich in parasites as soon as they came above ground, even before the first true leaves had developed. As all but the first lot of seedlings (which were grown in a greenhouse) were germinated in an incubator in the laboratory where there was no possibility of outside infection, there can be no doubt that this organism is transmitted through the seed of the host plant.

Three other flagellates have been described from plants of this family. *Leptomonas elmassiani* Migone was described from *Arauja angustifolia* in Paraguay and Uruguay, and from an *Asclepias* (probably *syriaca*) in Maryland, U. S. A. (Holmes, 1924); *L. bordasi* França was described from *Morreira odorata* in Paraguay; and an unnamed *Herpetomonas* was described from *Arauja angustifolia* in Italy by Franchini (1923 c). The organism under consideration differs



from each of these in the virtual absence of flagellate forms in the latex, in the general dimensions, and in the shape of the elongated individuals.

A PARASITE OF THE LATEX *Hieracium aurantiacum* L.

(Plate II)

*H. aurantiacum* is a common and troublesome weed in many parts of the Province of Quebec. In the neighborhood of Macdonald College there are a few localized areas in which it may be found thriving. Examination of the latex showed the constant presence of an elongate organism of the type described below, in leaves, stem and runners. The plants were apparently healthy. In the autumn a number of plants were transferred to two large flat boxes in the greenhouse. The old stalks died and new ones came up which were remarkably robust and healthy in appearance. There was no perceptible growth during the winter months although the plants retained their healthy appearance and all the leaves were fresh and of a rich green color. Examinations were made at frequent intervals. Shortly after the plants were placed in the greenhouse the elongate parasites disappeared and only the small round or oval resting forms could be found. The organisms continued in this condition all winter although there was an abundance of latex and the temperature and other external conditions were apparently favorable. In March the plants started growth again and frequent examination showed an increasing number of elongate forms. There is thus apparently a rhythmic adaptation of the life-history of the parasite to that of its host.

Four types of the parasite may be recognized in the latex: (1) elongate forms; (2) large spherical or oval forms; (3) small resting forms; and (4) irregular forms.

The elongate forms are extremely variable in shape and size. They may be: (a) spirally coiled with one, two or three turns; (b) irregularly coiled and twisted; or (c) uncoiled and symmetrical about the long axis. Some individuals are broadest at or near the middle tapering more or less regularly towards both ends. Others have a uniform breadth except at the extremities which are usually somewhat narrowed. The extremities may be alike (both blunt or both pointed), or unlike. In the spring when growth is most active some extremely long, vermiform individuals are found. At this time, too, a few forms with short flagella are present in the latex. The length varies considerably; the smaller individuals may be 10 to 20 $\mu$  long, but individuals measuring as much as 70 $\mu$  are occasionally found. The average width is about 3 $\mu$  but varies between 1 and 6.5 $\mu$  in the preparations examined. The protoplasm of these elongate forms is

DU PORTE—ENDOPHYTIC PROTOZOA



PLATE XXVIII

EXPLANATION OF FIGURES

Organisms from Latex of *Asclepias syriaca*. (Iron hematoxylin and Giemsa preparations). A. Round bodies, small and large. B. Dividing bodies. C. Elongate active forms; (a) two organisms with rudimentary flagella.

DU PORTE—ENDOPHYTIC PROTOZOA

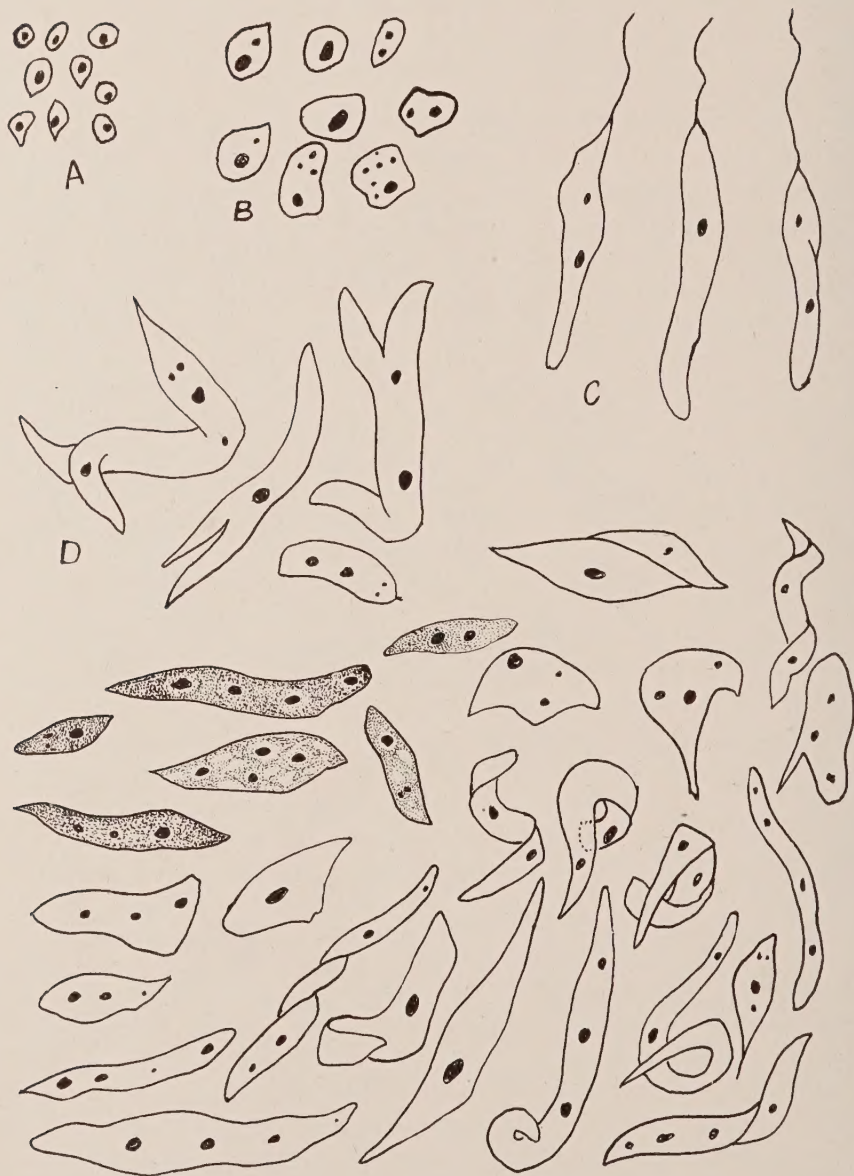


PLATE XXIX

Organisms from latex of *Hicracium aurantiacum*. A. Small round bodies. B. Large round bodies. C. Forms with short flagella. D. Dividing forms.



DU PORTE—ENDOPHYTIC PROTOZOA

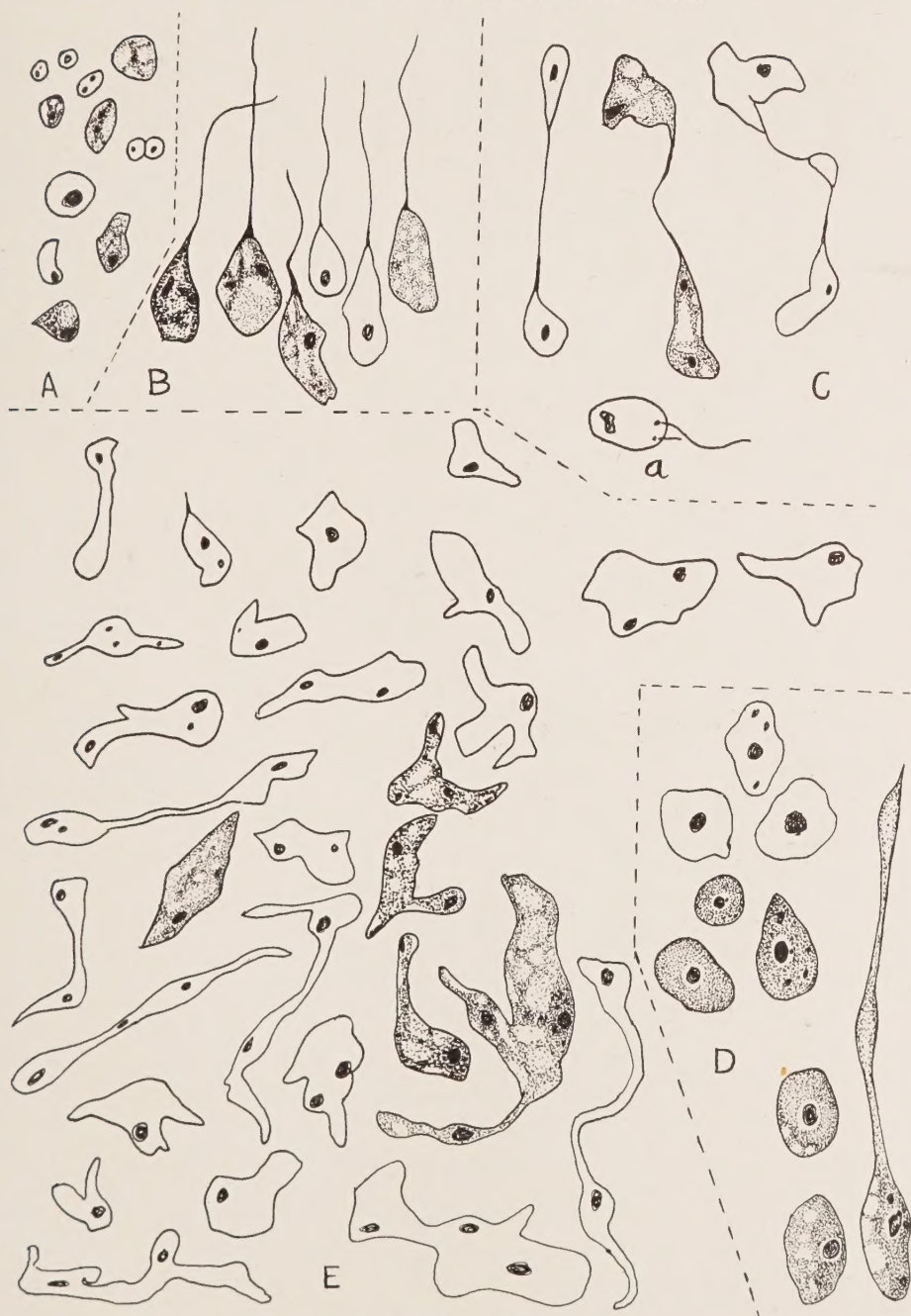


PLATE XXX

Organisms from latex of *Convolvulus sepium*. A. "Round" bodies. B. Cells with flagella or flagellum-like processes. C. Dividing forms; (a) cell about to undergo typical "leptomonad" division (the only one observed). D. "Type B." E.

DU PORTE—ENDOPHYTIC PROTOZOA



PLATE XXXI

Organisms from latex of *Morus alba*. A. Small round bodies. B. Dividing cells. C. Encysted cells; (a) cast cyst wall.



sometimes homogeneous, sometimes irregularly reticulate. The nucleus is small, sometimes single, usually two or several.

The large round or oval forms are about 3 to 6 $\mu$  in diameter, sometimes with a single nucleus which may be central or eccentric, sometimes with two or more nuclei. Their protoplasm is granular. The resting forms are usually round, sometimes oval or pyriform. They measure from 1 to 3 $\mu$  across. It is often difficult to obtain the details of their structure in stained preparations, but some Giemsa preparations showed a large blue nucleus, central or eccentric, surrounded by a pink ring of clear homogeneous protoplasm. Thus stained they are somewhat reminiscent of a Romanowsky preparation of lymphocytes. They are most abundant in winter and spring.

A PARASITE OF THE LATEX OF *Convolvulus sepium* L.

The hedge bindweed is a common plant cultivated, or growing wild, along hedges and fences. It has a scanty and dilute latex in the leaves and the tips of the stems. Both wild and cultivated plants are parasitized by amoeboid latex organisms. The parasitized plants appear to be absolutely healthy. The organism passes the winter in the perennial roots of its host and pass from these into the new shoots in the spring. This organism, like that found in the latex of *Asclepias syriaca*, is capable of being transmitted from generation to generation through the seed. Seedlings grown in the greenhouse during the winter from seeds of the previous autumn contained numerous organisms in the latex.

I have distinguished two types on the structure of the cytoplasm.

TYPE A. Numerous small round or oval forms (Plate III A) occur, the smallest measure 1 $\mu$  or less in diameter, and they grade with no perceptible break into the larger forms, which may measure 6 or 8 $\mu$ .

Pyriform or irregularly ovate individuals (Plate III B) are found in most preparations measuring 5 to 8 $\mu$  in length and 2.5 to 3.5 $\mu$  in breadth, and bearing at the narrow end a flagellum-like protoplasmic process 6 to 12 $\mu$  in length.

The majority of this type are irregular or amoeboid in form. The irregularity is sometimes slight, sometimes very marked, giving the organism an extremely bizarre appearance. There are often several processes; or part of the cytoplasm may be drawn out to a great length. Most of these forms are of dimensions similar to or slightly greater than the forms previously described but many of them are very much larger, commonly measuring 20 to 40 $\mu$  in length, occasionally as much as 70 $\mu$ .

Dividing forms (Plate III C). Two individuals are often found united by a long tenuous thread. This has been interpreted as a stage in the multiplication of the organism. The ultimate fate of the con-

necting strand is unknown. Possibly it persists as the "flagella" described above. It is interesting to note that Franchini (1923 d) has described a somewhat similar phenomenon in a flagellate parasitic in the latex of *Ficus benjamina*. This flagellate sometimes divides transversely by a constriction about its middle and a subsequent drawing out (*étirement*) of the constricted area. The connecting thread is finally broken in the middle and the two halves form the flagella of the daughter cells. In examining upwards of a hundred slides I found a single individual in the early stages of a typical leptomonad division (Plate III a). This may be a quite distinct form.

TYPE B. Occasionally forms are found with dense, granular, homogeneous protoplasm, and with a single large and distinct nucleus usually placed at or near the center of the organism. The nucleus usually has a densely stained punctiform chromatin body near or in it, and other small chromatin masses are scattered in the cytoplasm. These organisms are usually round or broadly oval, fairly regular in outline and range from 7 to 20 $\mu$ , the majority being 8 to 12 $\mu$  in diameter. A single individual of this type was found with one end drawn out into a long process having two slight enlargements. This individual measured 74.5 $\mu$  in its total length, and was 8.5 $\mu$  at its broadest point. This type may be distinct from the other, but intermediate forms having the cytoplasm partly granular and partly vacuolate have been found.

#### A PARASITE OF THE LATEX OF *Morus alba* L. (Plate IV)

The latex of five white mulberry trees growing on the college grounds was found to be infected although the trees were apparently healthy.

In the autumn and spring, when there are no leaves and the concentrated latex is found only in the branches and larger twigs, the parasite occurs in large numbers. In the summer, when the latex in the young leaves and growing twigs is more dilute, the number found in any one preparation is much smaller.

The parasite is fairly uniform in size and shape, varying from spherical through oval to more or less spindle-shaped forms. No very long narrow forms are present in the latex, but individuals of irregular outline are common. The average length is about 7 $\mu$ . Occasionally giant forms occur, the largest found being 25 by 12 $\mu$ . Small round resting forms are also common. The cytoplasm is granular, sometimes vacuolate. The nucleus is usually round, sometimes elongate or irregular. There may be a single nucleus but, commonly two or more, are seen. Small chromatin bodies are also commonly present.

Encysted forms are sometimes met with. The cyst wall is delicate with many small vacuoles or lacunae, and often contains a few dark-

colored granules. Discarded cyst walls with the contained granules are found in many preparations. Dividing individuals are always present. The common method of division is by binary fission. The daughter cells may be subequal or very unequal in size. Indications of multiple fission are also met with. Division within the cyst has also been observed.

#### THE RELATION OF INSECTS TO THE ENDOPHYTIC PROTOZOA

As early as 1911 Lafont described an insect vector of *L. davidi*. Since that time several other hemipterous insects have been shown to be concerned in the transmission of this organism. França (1924) describes a cyclic development of *L. davidi* in the digestive tract and salivary glands of the hemipteron *Stenocephalus agilis* Scop. He regards this insect as the primary host and the other insects implicated in transmission as accidental or mechanical carriers. In instances of this kind it is usual to regard the insect as the primitive, and the plant or vertebrate animal as a later host to which the parasite has more recently become adapted. Undoubtedly in many cases this is true, but it seems that the alternative position is equally tenable. If the parasitic habit among protozoa arose through the invasion of organs and tissues by saprophytic organisms, and the adaptation of these organisms to parasitic life, then the most ready mode of entrance would be with the food of the host. For insects feeding on solid substances, or for those which imbibe water, the ingestion of saprophytic organisms must be continually taking place. The hemipterous insects, however, obtain their food and water from the internal juices of plants and animals, and in most cases the ingestion of foreign organisms except in the juices of the hosts, is extremely unlikely. Moreover, the association of the Hemiptera with plants and animals has been of long duration. The hemipteron stem probably arose in the Upper Carboniferous, and the earliest protohemipteron, from the Lower Permian, already has its mandibles and maxillae modified to form the distinctive elongated piercing stylets of the group. For ages, then, the food habits of the Hemiptera have been such as to practically exclude the likelihood of ingesting saprophytic protozoa unless these are already associated with the host of the insect. It is quite probable, therefore, that at least some of the endophytic protozoa may have primitively invaded the latex of plants, and later become adapted to living in the tissues of the insects which feed on these plants.\*

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\* A parallel course of adaptation is also probable among animal parasites since it has recently been shown that yeast-like bodies and protozoa, characteristic inhabitants of the digestive tract of man, are capable of passing into the blood stream. (Fleisher, Moyer and Wachowiak in Am. Journ. Trop. Med., 1921. Ely, Kofoed et al in Calif. State Jour. Med., 1922.)



According to Galli-Valerio (1920), a more primitive degree of the adaptation of a saprophytic protozoan to an internal parasitic life than obtains in *L. davidi*, is to be found in *Herpetomonas pyrrhocoris*. This flagellate occurs in the hemipteron *Pyrrhocoris apterus* which feeds on *Colchium autumnale*. In the spring the blossoms of *C. autumnale* decompose forming a brown semi-fluid mass which contains an abundant saprophytic fauna. In this decomposing matter the flagellate reaches the intestine of the bug, multiplies, and is deposited again in autumn on the blossom with the insect's excreta.

Protozoal parasites of insects, whatever their origin, may secondarily became parasitic in laticiferous plants since latex seems to be an excellent culture medium for both protozoa and bacteria. Franchini (1923 c) inoculated flagellates from *Musca domestica*, *Sarcophaga haemorrhoidalis*, *Calliphora erythrocephala* and *Pentatomum ornatum* into *Euphorbia geniculata* and *Eu. exula*. All the inoculated plants were distinctly paler than the checks. The lower leaves withered, the others turned yellowish. The flowers and seeds were less numerous. The latex was aqueous. The starch grains were fewer and often swollen and distorted and in the very unhealthy plants rare or lacking. Leishmaniform bodies were detected in the latex.

#### RELATION OF ENDOPHYTIC PROTOZOA TO THE HEALTH OF HOST PLANTS

*Leptomonas davidi* has been shown to be definitely associated with a gummosis of *Euphorbia*. In several other cases the plants parasitized have been described as showing marked symptoms of disease. Franchini (1923 b) describes a parasitized *Euphorbia cereiformis* as pale, decidedly unhealthy, with thin latex having the starch grains few and deformed. Of three plants of *Arauja angustifolia* examined in Bologna, two were healthy and covered with leaves and flowers. The third was yellowish, without flowers, and bore leaves only at the extremities of the branches; the latex was decidedly more aqueous in consistency than in the two healthy plants. The two healthy plants were not parasitized, while the third contained numerous motile flagellates in its latex (Franchini, 1923 e). Seriously diseased cabbages were found to be infected with *Herpetomonas*, *Crithidia* and *Trypanosoma*. Franchini (1923 g) regards an unhealthy condition of the plant as a normal accompaniment of protozoal infection, and thus describes the general symptoms: "Une partie des plantes parasitées sont malades, elles jaunissent, se flétrissent, leurs feuilles tombent, leur développement est sérieusement entravé."

On the other hand, there are records of protozoal infection without pathogenic symptoms. In Bologna, Franchini (1923 f) found *Euphorbia grandidens* and *Eu. nercifolia* infected but healthy. Infected lettuce (1922) seemed unhealthy but similar symptoms were found in plants which were not infected. *Arauja angustifolia* parasitized by *Leptomonas elmassiani* Migone appears healthy. As pointed out above I have not been able to associate any pathogenic symptoms with the presence of protozoa in any of the plants studied. In individual cases infected plants have shown symptoms of general unthriftiness, but other individuals of the same species heavily infected have appeared healthy and robust. It is probable that here are varying conditions of more or less complete adaptation between the parasites and their hosts; conditions of adaptation similar, for instance, to those found between the various trypanosome groups and their vertebrate hosts. In the four forms described above apparently one finds an almost perfect adaptation of parasite to host. The activity of the parasite coincides with that of the host. As winter approaches resting forms develop which overwinter in the permanent parts of the host. Even when external conditions are apparently quite favorable (as in *H. auran-tiacum* in greenhouses during winter) the parasite remains inactive until the host resumes its growth. Finally, in at least two species there is adaptation for hereditary transmission through the seed. This all points to a long-continued association of parasite and host. On the other hand, protozoa from various insects, introduced into the latex of Euphorbias, which they presumably do not normally parasitize, bring about marked symptoms of disease (Franchini, 1923 a).

One must not overlook the possibility that certain serious plant diseases of unknown or obscure etiology may be due to protozoa. A good illustrative case is to be found in the curly-leaf disease of beets. This disease is associated with the beet leaf-hopper *Eutettix tenella* Baker. That the pathogenic symptoms are not caused directly by the insect is shown by the failure of insects obtained from certain wild plants to bring about these symptoms in the beet. The most significant suggestion of the probable protozoal nature of the causal organism is to be found in its apparent requirement of an incubation period in the gut of the insect host before the latter becomes infective. Certain workers claim to have found protozoan-like bodies associated with mosaic diseases, but I shall not venture to make any suggestion regarding the etiology of these puzzling and elusive maladies.

#### RELATIONS OF ENDOPHYTIC PROTOZOA TO THE HEALTH OF MAN AND ANIMALS

One of the most important and interesting phases of this subject is the relation of the endophytic protozoa to the health of man. Do

plants serve as reservoirs for certain of the known diseases of man? Will the accidental ingestion or inoculation of the protozoa parasitic in plants bring about a diseased condition in man? A comparison can be readily drawn between the development of the insect flagellates in the secondary vegetable and animal hosts, and also between the effects on these hosts. In both cases the flagella are sometimes lost and leishmaniform or amoeboid bodies develop. In animals one often finds the destruction of the red corpuscles and consequent thinning of the blood. In plants there is a similar thinning of the latex due to the destruction of the starch grains. A superficial comparison might also be made between the resultant anemia in the one case and the paling of the leaves in the other. If plants serve as reservoirs, the incidence of certain diseases such as leishmaniasis may be readily explained.

The evidence for a probable connection between these organisms and animal diseases is three-fold: (1) that gained from the behavior of the organisms when cultured in blood media; (2) the possibility of growing known pathogenic human parasites in latex and bringing about disease in plants; and (3), the results of direct inoculation of endophytic protozoa into animals.

Migone (1916) succeeded in obtaining a rich and active culture of *L. elmassiani* on human blood-agar. Franchini has grown a number of endophytic amoebae and flagellates on various blood media and has observed them ingesting the red corpuscles.

Franchini (1923, 1923 a) has succeeded in culturing several parasitic protozoa in the latex of plants or in a mixture of latex and nutrient broth. Among others, he cultured the following well-known forms: *Trypanosoma lewisi*, *T. gambiense*, *T. brucei*, *T. cruzi*, *Leishmania furunculosa*, *Lambia intestinalis*, etc. He also succeeded in inducing typical disease symptoms in *Euphorbia ipecacuanha* by inoculating with *Leishmania donavani*, and in recovering the organisms from the latex.

With regard to the effect of inoculating animals with endophytic protozoa, Migone has shown that cultures of *L. elmassiani* are pathogenic to animals; Franchini has induced infection in a cat and in white rats by inoculating with parasitized latex; and Strong announced last December, before the Cincinnati meeting of the American Association that a leptomonad parasite of Euphorbias in Panama, Central America and South America, is pathogenic to mammals after having passed through the body of an insect (*Chariesterus cuspidatus*) and a reptile (*Cnemidophorus lemniscatus*). The evidence thus points to a possible relation between the endophytic protozoa and human health.



## SUMMARY

Since the discovery by Lafont in 1909 of *Leptomonas davidi* in the latex of *Euphorbia pilulifera* several investigators have added to our knowledge of the subject; at the present time records have been made of amoebae, leptomonads, trypanosomes and spirochaetes from a large number of laticiferous plants distributed over several families in many parts of the world.

The writer lists fourteen host plants of endophytic protozoa in Canada, and describes organisms found in the latex of *Asclepias syriaca*, *Hieracium aurantiacum*, *Morus alba* and *Convolvulus sepium*.

These organisms survive the winter in the perennial parts of the host (stems and roots) and become active as the growth of the host is resumed in the spring.

The organisms from *Convolvulus* and *Asclepias* may be transmitted through the seed.

There has been no definite association of pathological conditions with the presence of these four organisms.

The probability of these plants being the primitive host and insects the later host of the organisms, and the relation of the organisms to human and plant pathology are briefly discussed.

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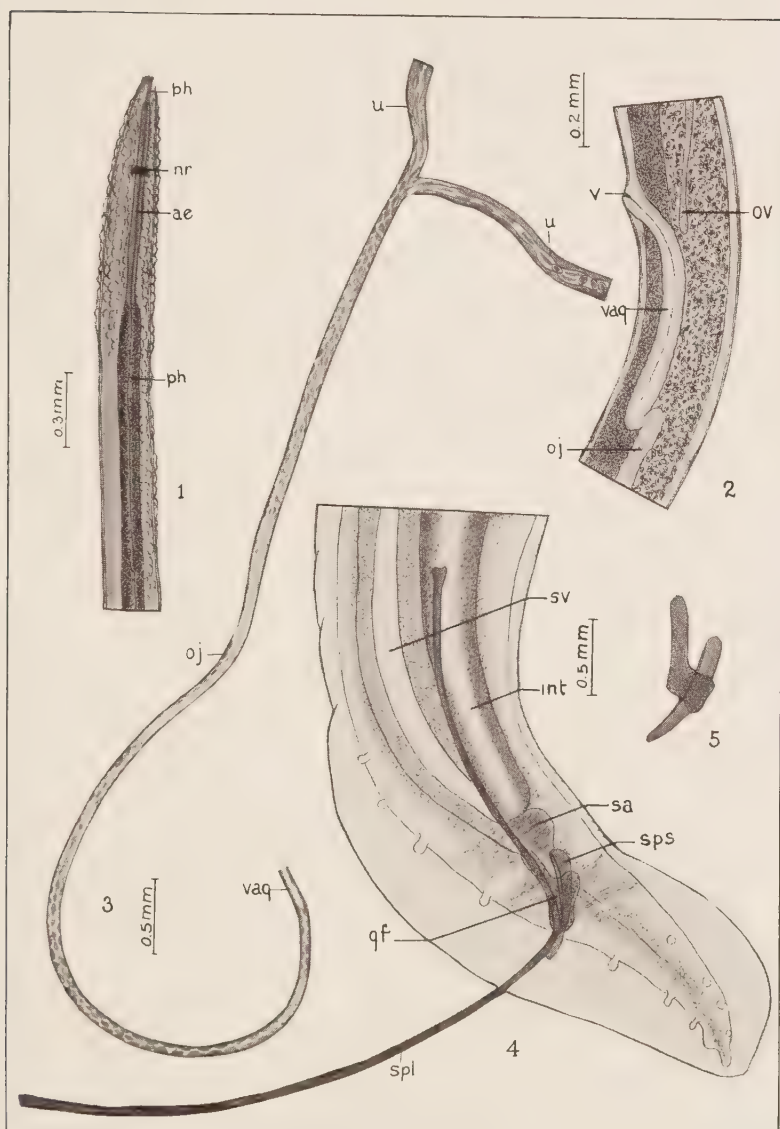


PLATE XXXII

EXPLANATION OF FIGURES

All figures represent *Gongylonema orientale*

Fig. 1.—Anterior portion of female. *B*, buccal cavity; *n r*, nerve ring; *a e*, anterior esophagus; *p e*, posterior esophagus.

Fig. 2.—Vulval region. *V*, vulva; *Oj*, ductus ovejector.

Fig. 3.—Vagina (*vag.*), ovejector (*oj*) and beginning of the uteri (*u*).

Fig. 4.—Posterior end of male with long spicule protruded by pressure. *spl*, long spicule; *sps*, short spicule; *gb*, gubernaculum; *sa*, sphincter ani, *sv*, distal portion of the seminal vesicle.

Fig. 5.—Short spicule and gubernaculum.





ON A NEW SPECIES OF NEMATODE, *GONGYLONEMA*  
*ORIENTALE*, FOUND IN FORMOSA

SADAMU YOKOGAWA

While working on the life history of *Physaloptera formosana*, which I found (Yokogawa, 1922) in the stomach of *Sorex* sp., I examined a great many kinds of insects in an attempt to determine the intermediate host of that parasite. During these examinations, I found a larval nematode in the muscles of the cockroach (*Periplaneta americana* and *P. australasia*). Thereupon, during an extended period, I fed four white rats each day with one to three cockroaches containing this nematode. Two of these died after a short course of the experimental feeding, while the other two were killed respectively on the fifty-seventh and seventieth day from the beginning of the experiment. At autopsy I observed some thickening of the mucous membrane of the stomach and in the thickened tissues, some nematodes. Examination of these parasites showed that they belonged to the genus *Gongylonema*. Since this form differs, in certain particulars from *G. neoplasticum*, I shall describe it as a new species under the name, *Gongylonema orientale* n.sp.

STRUCTURE OF THE ADULT WORM

The worm is long, filiform and slightly attenuated toward the two extremities. The cuticula is comparatively thick and finely striated transversely at intervals of 7 to 14 $\mu$ , according to the size of the animal. Anteriorly, in the vicinity of the proximal portion of the esophagus, the annulations disappear and are replaced by longitudinal rows of vesicular bosses, more or less globular, egg-shaped or sausage-shaped, and of very variable size (Fig. 1). The mouth is small and has the shape of an equilateral triangle but is without lips. The oral papillae are inconspicuous. No cervical papillae were observed. The excretory pore is in the median line on the ventral surface, half way between the nerve ring and the beginning of the posterior part of the esophagus. Posterior to the mouth is a short buccal cavity with a thin chitinous lining. The esophagus is divided into two parts; the anterior portion is short and slender and passes abruptly into the posterior portion, which is much thicker and longer and also more opaque. This portion is about twice as thick as the anterior portion and of fairly uniform diameter, increasing only slightly in the most posterior portion. The posterior end of the esophagus is separated from the intestine by a constriction and intestinal valves. The intestine is about as thick as the

anterior portion of the esophagus and runs along the ventral side of the body. The rectum is narrower and the anal musculature is well developed.

The male is very small compared with the female, being only 9 to 16 mm. long and 0.1 to 0.14 mm. thick. The anterior end of the body is a little narrowed while the posterior end is slightly twisted. The fore part of the esophagus is one-sixth of the hind part and the whole esophagus is one-fourth or one-fifth of the entire length. The nerve ring is situated at 0.21 mm. from the anterior end of the body in a male 15 mm. long. Measurements of ten specimens gave the following figures: The length of the body varied from 9 to 16 mm. with an average of 12.117 mm.; while the width varied from 0.095 to 0.15 mm., with an average of 0.129 mm. The buccal cavity had a length of from 42 to 70 $\mu$  with an average of 49 $\mu$ . The anterior region of the esophagus varies in length from 0.225 to 0.434 mm. with the average 0.335 mm.; while the posterior region has an average length of 2.364 mm. with a range from 1.82 to 2.805 mm. The total length of the esophagus varies from 2.17 to 3.094 mm. with the average at 2.722 mm. The length of the spicules was recorded for six of these individuals. The long spicule measured from 0.61 to 0.63 mm., with an average of 0.623 mm., and the short spicule had an average length of 86 $\mu$  and a variation from 80 to 94 $\mu$ .

The reproductive organs of the male consist of a single testis, vas deferens, vesicula seminalis, ductus ejaculatorius, two spicules, gubernaculum and bursa. The single testis originates near the posterior end of the esophagus with a small loop and runs along the dorsal side of the body. It terminates in a small knob measuring 30 to 36 $\mu$  in diameter. Posteriorly the testis is joined by the thick walled, narrow vas deferens, about 85 to 120 $\mu$  long and 20 to 30 $\mu$  thick. This opens into a long dilated cylindrical vesicula seminalis situated near the ventral side of the posterior part of the body, crossing the intestine. It measures 0.07 to 1.0 mm. in length with a varying diameter according to the quantity of spermatozoa present. Usually the proximal part of the seminal vesicle is full of spermatozoa, but they are not evenly distributed through the entire length.

The posterior end of the seminal vesicle continues at the ventral side of the rectum into the ductus ejaculatorius. This duct is short and, as a rule, closed by a well developed sphincter. When the spermatozoa come down to the posterior end of the seminal vesicle, the sphincter opens and the spermatozoa are driven out with great force by means of contraction of some part of the seminal vesicle. The spermatozoon has an egg or pear shaped body and a short tail. The body is 7 to 9 $\mu$  long and 4 to 5 $\mu$  wide; the tail is about 4 $\mu$  long. The spermatozoa show



almost no movement after discharge. The spicules are very unequal in size. They are both rather opaque but without the yellowish or brownish tinge often observable in spicules. In profile, the short one is sword-shaped with a rounded tip and is fixed at the dorsal side of the cloaca. It curves ventrad facing the gubernaculum which is to be found at the ventral side of the cloaca. It seems to be hollowed out along its ventral surface and to become thinner toward the tip. It can be protruded by pressure. The long spicule has its base between the seminal vesicle and the posterior portion of the intestine. Its distal end is found between the rectum and the ductus ejaculatorius. It is of almost uniform thickness throughout, except for a slight dilation at the proximal end. This dilated base is attached to a muscular bundle which governs the movement of the long spicule; this is movable antero-posteriorly inside its sheath that lies between the seminal vesicle and the distal portion of the intestine. Though it can be protruded by compression, it is, however, not commonly found protruded like that of *Gongylonema neoplasticum*. If the long spicule is protruded by compression, the protruded distal portion bends at a right angle to the proximal portion which is supported by the gubernaculum and the short spicule. The gubernaculum is found at the ventral side of the cloaca nearly parallel with and toward the distal end, slightly convergent toward the short spicule. It is almost transparent and colorless and, therefore, easily overlooked. It consists of a column and a branch. The column runs longitudinally and converges toward the distal end of the short spicule. The middle part of the short spicule forms a sort of articulation with the branch of the gubernaculum leaving space for the long spicule to pass (Fig. 5). The tail is slightly twisted and provided with a bilobular semilunar bursa. This bursa is asymmetrical, the left side being a third or a half shorter than the right; the long side is 0.42 to 0.53 mm. long and 0.04 to 0.05 mm. wide. While no distinct constriction can be made out in the middle as in *Gongylonema neoplasticum*, yet there are frequently traceable one or more faint transverse indentations, which however, from their varying situation, I am inclined to consider simply as the remnants of the striae of the over-distended cuticula. There are eight pairs of fungiform caudal papillae, placed somewhat asymmetrically; four pairs of them are placed in front of the anus and the others back of it; the four pairs of preanal papillae are the larger, being 18 to 20 $\mu$  long, while of the four postanal pairs those nearest the cloacal aperture are the largest, and their size decreases posteriorly, those nearest the tail appearing as rudimentally knobs.

The females are very unequal in size according to age, the number of parasites present and the size of the host. Not only is the size of the body variable but also the location of the vulva, so that one might

suspect the presence of different species. I think, however, that they belong all to the same species because such aberrant forms are very few compared with the ordinary condition. The body is almost uniform in diameter except at the ends, measuring 45 to 115 mm. in length and 0.23 to 0.37 mm. in width. The posterior end narrows rapidly behind the anus toward the tip of the tail. The anterior extremity of the body terminates in a blunt cone, the tapering beginning at the anterior part of the esophagus. This anterior part is one-seventh or one-eighth of the posterior one and the whole esophagus is one-eighth to one-thirteenth of the entire length of the body; exceptionally it may be only one-twentieth of the latter.

Measurements of ten females were as follows: length, average, 74 mm.; minimum, 45 mm.; maximum, 115 mm.; width, average, 0.319 mm.; minimum, 0.26 mm.; maximum, 0.37 mm. The length of the buccal cavity varies from 0.06 mm. to 0.12 mm. with an average of 0.074 mm. The shorter, narrower anterior portion of the esophagus has an average length of 0.831 mm. with a variation from 0.68 mm. to 1.12 mm. and the longer, thicker portion has an average length of 0.113 mm. and varies from 4.85 mm. to 7.5 mm.

The reproductive organs of the female consist of a pair of ovaries, oviducts, receptacula seminis, uteri and a long ovejector, vagina and vulva. In the adult female some of these parts are seen with difficulty, because most of the body is filled up with wide loops of the uteri containing many eggs. On the other hand, the course of the reproductive organs can be seen clearly in the young female. Accordingly when one has become familiar with the conditions in the young female, there is no great difficulty in tracing the reproductive organs in the adult by dissection. The vulva has prominent lips and is situated near the posterior extremity usually at 5 to 10 mm. from the tip of the tail, that is at a distance of one-eighth to one-tenth of the body length. The vagina is long and cylindrical in shape, extending anteriorly from the vulva in a slight arch with a length of 0.6 to 0.9 mm. It is supplied with well developed muscles and is lined on the inside with a cuticula. The ovejector is also very long, having a length of 7 to 10 mm. with a lining of cylindrical epithelium on the inside like that of the uteri. It runs anteriorly from the vagina for a long distance, the uteri diverging usually at the beginning of the posterior one-third of the body. In a specimen 55 mm. long, I found the length of the vagina to be 0.87 mm. while the ovejector was 8.54 mm. long. The anterior uterus becomes the receptaculum seminis anterior near the posterior end of the esophagus and joins the ovejector at the posterior one-third of the body, forming several loops parallel to the axis of the body. The receptaculum seminis is shaped like a bomb shell, having a length of 0.5 to 0.7 mm. Its anterior extremity

is narrow and joins a short oviduct. The oviduct is a relatively thick-walled tube 0.7 to 0.9 mm. long that forms a loop near the posterior end of the esophagus and connects the ovary with the receptaculum seminis. The anterior ovary is directed posteriorly near the middle of the body and afterward much looped, with the long axis of the loops parallel to that of the body. The posterior ovary has its initial portion near the vulva, directed anteriorly and joins a posterior oviduct near the rectum, making a few longitudinal loops. The posterior oviduct is a little shorter than the anterior one and joins the posterior receptaculum seminis, making a curve near the rectum. The posterior seminal receptacle is similar to the anterior one and joins the posterior uterus after running anteriorly near the posterior extremity of the body. The uterus runs anteriorly from this point to the ovejector, forming several longitudinal loops passing through the vulvar region. In the full grown female, the uteri are filled with eggs and more or less cover up the other organs. The eggs are regularly ovoid and always contain embryos when deposited; they are 54 to 58 by 34 to 37 $\mu$ . The average size in 15 measurements was 57 by 33 $\mu$ . The shell is thick, refractive and colorless and in optical section it appears somewhat thickened at the poles.

Looking over the above description, one finds that while the general characters of this worm are similar to those of *Gongylonema neoplasticum*, there are certain structural differences which are placed side by side in the table. (See next page.)

Comparing carefully the above descriptions, one finds that the new parasite differs from *Gongylonema neoplasticum* in several points of its anatomical structure. This parasite may reach maturity within 35 to 42 days after experimental infection, eggs being found in the feces on those days, while in *G. neoplasticum* growth to maturity is said to require two months. The male of the new species may become sexually mature even within 20 days, some spermatozoa being found that early in the seminal vesicle. All these points tend to confirm the opinion that it is a new species of *Gongylonema*, however similar its biological character to that of the old species.

*G. orientale* is parasitic in rats and other rodents on the mucous membrane of the anterior portion of the digestive tract as far as it is covered with squamous cells, namely in the anterior half of the stomach, esophagus, tongue and mouth. These worms set up marked pathological alterations in the same way as *G. neoplasticum*. The process begins as a circumscribed area of diffuse hypertrophy of the mucous membrane, goes on to the formation of papilloma and terminates in carcinoma with occasional metastases.



TABLE 1

Sex	Point of Comparison	<i>Gongylonema neoplasticum</i>	<i>G. orientale</i> nov. spec.
Male	Size .....	Length 15 to 20 mm.; thickness 0.11 to 0.13 mm.	Length 9 to 16 mm., thickness 0.095 to 0.15 mm.
	Length of esophagus	One-fourth entire length of body	One-third to one-sixth of entire length of body; average one-fourth of entire length of body
	Tail .....	Spirally twisted.....	Slightly twisted
	Bursa .....	Asymmetrical, one side one-third shorter than the other; elongately oval with distinct constriction in the middle; more pronounced on longer side and placed more posteriorly on the shorter side; average length 0.462 mm., width 0.17 mm.	Asymmetrical, left side one-third to one-half shorter than right; no distinct constriction in the middle; longer portion 0.42 to 0.53 mm. long, 0.04 to 0.05 mm. wide
	Long spicule.....	Average length 0.528 mm.; commonly found protruded to half its length, protruded distal portion being bent at right angles, to proximal portion.	Average length 0.622 mm.; almost uniform like a long whip and commonly found between seminal vesicle and intestine, but it may be protruded by pressure
	Short spicule.....	Sword shaped with a rounded tip, tapering toward tip; average length 93 $\mu$ , maximum with 9 $\mu$ .	Similarly shaped; length 73 to 94 $\mu$ , width 9 to 16 $\mu$
	Gubernaculum ....	Not described .....	Found at ventral side of cloacal aperture, facing toward short spicule; consists of a column and a branch, latter joins middle part of short spicule, leaving a passage for long spicule
	Vas deferens.....	Average length 70 $\mu$ .....	Length 85 to 120 $\mu$
	Spermatozoa .....	Small regular globular cells....	Consist of ovoid or pear-shaped body and tail; body 7 to 9 $\mu$ long, 4 to 5 $\mu$ thick; tail 3.5 to 4 $\mu$ long
	Size .....	Length 60 to 80 mm.; thickness 0.17 to 0.326 mm.	Length 45 to 115 mm.; thickness 0.26 to 0.35 mm.
Female	Length of esophagus	One-ninth of body length.....	One-eighth to one-thirteenth of body length
	Vulva .....	Near the posterior end of body, not prominent	Near posterior end of body, usually prominent
	Vagina .....	Extends anteriorly for a short distance	Long, and extends anteriorly from the vulva 0.6 to 0.9 mm., forming a slight arch
	Uterus .....	Anterior uterus becomes receptaculum seminis near posterior end of esophagus; posterior uterus does the same behind vulva	Anterior uterus becomes receptaculum seminis near posterior end of esophagus and posterior one near posterior end of body
	Ductus ovejector..	Uteri divergent from the vagina; accordingly no ovejector	Very long, 7 to 10 mm.
	Size of eggs.....	Length 60 $\mu$ , width 40 $\mu$ .....	Length 57 $\mu$ , width 34 $\mu$

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THE ARTHROPOD ENEMIES OF MOLLUSKS, WITH  
DESCRIPTION OF A NEW DIPTEROUS  
PARASITE FROM BRAZIL

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The Mollusca are, next to the Arthropoda, the largest phylum of the Animal Kingdom. They exist in innumerable species in the sea, in fresh waters, and on land, where they frequently occur in populous colonies. It might therefore seem that their soft and succulent bodies would be an important item in the diet of the many carnivorous arthropods. Yet such is not the case. In the light of our present knowledge rapacious snails appear to be the most formidable predaceous enemies of mollusks. Against predatory arthropods, snails and bivalves are generally well protected by a calcareous shell, the aperture of which is frequently obstructed by folds or teeth, or in some species may be completely closed with an operculum. In the case of the bare-bodied slugs, the violent contractions of the body and the abundant slimy secretion of the skin seemingly are quite effective repellents. Moreover, the secretive habits of snails and slugs contribute much to their personal safety. Many species are strictly nocturnal or crawl about during rainstorms only, that is when most of their potential enemies are inactive. At other times they are safely hidden in inaccessible recesses or buried in the soil, often at great depth.

Among lower arthropods several species of mites (Acarina) infest land mollusks. Thus *Erynetes limaceum* Koch is commonly found in Europe on the slug *Limax maximus* Linnaeus and some of the Helicidae, retiring upon occasion into the pulmonary chamber (Cooke, 1895:62). In North America a mite (*Hypopus concolor* Haldeman) has been recorded by Binney as found upon a snail; it may have been a nymphal form of Erynetes. I have observed minute, ectoparasitic mites on a living Achatina in the Semliki forest of the Belgian Congo. Stuhlmann (1894:313) had found them before in the same region with *Achatina schweinfurthi* v. Martens and *A. stuhlmanni* v. Martens. The acarids that parasitize fresh-water mollusks are much better known. They are aquatic mites (Hydrachnidae) of the genus *Unionicola* Haldeman (= *Atax* Fabricius) and are most frequently found in the naiads or Unionidae, where they often are fixed on the gills. They are said to feed on the microscopic animals drawn in by the mussel. Küchenmeister (1856) has shown that they may become the center of a pearl growth, although this more commonly is formed around an

encysted parasitic worm. Species of *Unionicola* have been described from fresh-water snails also (Wolcott, 1899).

Certain carnivorous beetles appear to be quite efficient enemies of snails. Recluz, in Southern France, observed *Staphylinus olens* Müller attacking *Helix ericetorum* Müller, the snail being slowly killed by repeated bites (Petit de la Saussaye, 1852). A number of Carabidae do likewise and the Cydrinae of North America and Europe specialize in a snail-diet, their long, snout-like head rendering it possible for them to remove the animal far into the coils of the spire. Mr. C. W. Johnson informs me that in the Berkshire Hills, Massachusetts, he has frequently observed *Cydrus* devouring Helicidae that were crawling about on rainy summer days. The family Thelephoridae contains many species whose larvae feed exclusively upon snails. Lucas (1842) describes how the larva of *Drilus mauritanicus* Lucas, in Algeria, manages to enter the shell of live *Cyclostoma*, notwithstanding the operculum with which the aperture can be tightly closed. The larva patiently awaits the moment when the snail brings the operculum ajar, then suddenly wedges the mandibles between the operculum and the edge of the aperture, and attacks the muscle which fixes the operculum to the foot, so that the aperture can no longer be locked. It then leisurely devours the contents of the shell. The common European *Drilus flavescens* (Rossi) and the rarer *D. concolor* Ahrens have similar habits: their larvae destroy large quantities of *Helix nemoralis* Linnaeus, *H. ericetorum* Müller, and many other Helicidae (Mielzinsky, 1824; Crawshaw, 1903; Rosenberg, 1909; and Schmitz, 1909). Snail-eating habits are perhaps the rule for all members of the subfamily Drilinae and they are commonly met with among the Lampyridae too, a group of beetles well known as fire-flies or glow-worms. Thus Godard (quoted by Petit de la Saussaye, 1852:101) states that the larvae of some of the European *Lampyris* each consume two or three *Helices* before pupating. The same observer describes the method used by adult *Silpha laevigata* Fabricius and *S. atrata* Linnaeus, European beetles of the family Silphidae, to break the shell of small *Helices* that form a large part of their food: the beetle grasps the margin of the aperture between the mandibles and, suddenly jerking back the head, pounds the snail against the hard, chitinous plate of the prothorax. Among aquatic Coleoptera, Dytiscidae prey freely upon fluviatile snails. In Europe *Dytiscus marginalis* Linnaeus is said to prefer *Lymnaea stagnalis* (Linnaeus) to other snails (Williams, 1889); although accumulations of shells of *Planorbis corneus* (Linnaeus) with the sides of the whorls bitten away to allow of easy access to the animal, have been recorded as the work of this beetle (Taylor, 1900:419). Moreover, according to H. Blunck (1916:279), *Dytiscus marginalis* attacks



any kind of aquatic animal that is not too swift or too small, but shows no particular predilection for mollusks.

It has been asserted that certain ants at times destroy terrestrial snails (Lawson, 1920), but the pertinent observations are not conclusive. It is much more likely that the shells which are frequently found on or near the mounds of ants, are merely dead specimens that were gathered, together with pebbles, bits of wood, and like objects, in order to build a protective cover at the entrance of the nest.

Many interesting observations have been made in recent years on the Diptera that feed upon mollusks, notably by H. Schmitz (1917) and D. Keilin (1919 and 1921). Since these two authors have given comprehensive accounts of all cases known to them, it will suffice to call attention to some additional records. E. Séguéy (1921) in a brief note relates how *Sarcophaga melanura* Meigen, *S. carnaria* Meigen, and *S. soror* Rondani occasionally devour living, healthy *Helix aspersa* Müller in France. He observed a living slug, *Arion fuscus* (Müller), carrying a number of young dipterous larvae which eventually killed the mollusk and developed into *Sarcophaga melanura*. In addition Séguéy records the following saprophagous flies as feeding upon decaying snails: *Calliphora erythrocephala* Meigen, *Phora giraudi* Egger, *Muscina stabulans* (Fallen) (which, he says, might be a true parasitoid), *Fannia canicularis* (Linnaeus), *F. scalaris* (Fallen) and *Ravinia haematodes* (Meigen). L. Mercier (1921:164), in France, bred one of the Sciomyzidae, *Salpicella fasciata* (Meigen), from living *Helix pisana* Müller. Another member of the same family, *Sciomyza dubia* Fallen, was previously reared by Oldham, in England, from small terrestrial snails (quoted by Keilin, 1921:182). Of still greater interest is Lundbeck's (1923) recent discovery that certain European Sciomyzidae live as larvae upon the contents of fluviatile snails and most probably attack the live mollusk. His observations were made in Denmark, where the pupa of *Calobaea bifasciella* (Fallen) was found exclusively in *Lymnaea truncatula* Müller, closely attached within the aperture of the empty shell. The pupa of *Ctenulus pectoralis* (Zetterstedt) occurs in *Planorbis vortex* (Linnaeus), fixed sometimes a whole whorl away from the aperture. A third species, *Ctenulus punctatus* Lundbeck, was bred from several snails, most commonly from young specimens of *Planorbis planorbis* (Linnaeus), but also from *P. albus* (Müller), young *P. corneus* (Linnaeus), and *Lymnaea peregra* Müller. Mokrzecki (1923) found muscoid larvae in living *Buliminus bidens* Kryn, near Simferopol, Crimea. The adults which he reared were identified as *Muscina stabulans* (Fallen). He also claims to have bred *Fannia scalaris* (Fallen) from larvae that had apparently left the same species of snail. A number of Sarcophagidae are known to breed in terrestrial mollusks and a new genus of this family with similar habits

is described in the present paper. An additional North American case may be published on this occasion. Some time ago Mr. Wm. T. Davis, of Staten Island, communicated to me several specimens of *Sarcophaga parallela* Aldrich (identified by Mr. J. M. Aldrich), which he bred in October, 1908, from dead *Polygyra thyroides* (Say), collected at Inwood, New York City.

A few other incomplete records of dipterous larvae attacking freshwater snails have been published. Thus Pelseneer (1920: 79, Fig. 24; 115, Fig. 79; and 584) figures the larval tube of a "*Chironomus*" fixed upon the outside of the shell of *Physa fontinalis* (Linnaeus) and claims that the larva was responsible for a reduction of the digitations of the snail's mantle edge and even for a bifurcation of the posterior end of the foot. From what is known of the habits of chironomid larvae, it is a question whether this was a case of true parasitism. Larvae of *Chironomus* sp. were also recorded by K. H. Barnard (1911) as living in the mantle cavity of *Lymnaea peregra* Müller, in England, but this too needs verification, especially with regard to the feeding habits of the larva. Van Hyning (1919) found in Iowa dead specimens of *Physa integra* Haldeman enveloped in what was said to be an insect case.

The Diptera associated with mollusks belong to three ethological types. (1) Scavengers.—The majority of the Diptera bred from mollusks appear to be saprophagous species. They are attracted by diseased, dying, or putrefying mollusks, on which they oviposit. Usually there is no particular choice involved, but the larvae develop equally well in any other decaying animal matter. Foremost in this group are a number of Phoridae, which may be easily baited with crushed or decaying snails and mussels. Keilin (1919: 449-450) has given a list of phorids bred from dead mollusks in Europe and I have obtained several species under similar conditions in Africa (Schmitz, 1916). R. Senior-White (1924) has recently described additional species from Ceylon. Several of the Sarcophagidae bred from snails apparently are mere scavengers. This is likely the case with the North American *Sarcophaga (Helicobia) helcis* (Townsend) and *S. parallela* Aldrich. Both species were obtained from dead *Polygyra thyroides* (Say), but they have also been bred from dead and living arthropods. Of the many other species of flies recorded by Keilin (1919: 446-451) as "saprophagous larvae and doubtful parasites," some appear to be true parasitoids, although perhaps under certain circumstances only or without decided specificity for a molluscan host.

The ethological study of the scavenger flies is not without interest, for they evidently present us with the beginning stages of what has eventually led to the parasitic and parasitoid behavior. Moreover, there are some species with which this evolution is going on at present. Thus

the larvae of the house fly, *Musca domestica* Linnaeus, commonly develop in decaying vegetable substances. Yet Séguy (quoted by Keilin, 1919:451-452), in France, bred them on one occasion from terrestrial snails, of which they apparently attacked living and healthy individuals. It is of interest that similar genetic relationships may be traced in the behavior of certain muscoid scavenger flies that occasionally become parasitoids of vertebrates, causing some of the affections known as myiases.

(2) Ectoparasites. Certain wingless flies of the family Phoridae live, in the adult stage, upon the huge snails of the genus *Achatina*, in the moist rain forests of Africa. Three species are known at present, all belonging to the genus *Wandolleckia*. Cook (1897) discovered *W. achatinae* Cook "in the deep forests of Liberia, where it is found actively running about on *Achatina variegata* Roissy, the largest West African land snail." Wandolleck (1898) described and figured these flies as "Cook'sche Gattung" and added the following remark: "They seem to feed on the slime of the snails. They are very swift runners; when disturbed they leave their host very quickly, but return to it later." The name *W. cookei* Brues (1903, Trans. Amer. Ent. Soc., XXIX, pp. 337, 392, and 400) was proposed in the belief that Cook's species had never been named and is a synonym of *W. achatinae* Cook. The habits of *Wandolleckia indomita* Brues (1907, Ann. Mus. Nat. Hungar., V, p. 412), of Kibosho, Tanganyika Territory, are unknown. The third species, *Wandolleckia biformis* H. Schmitz (1916), I found during my stay at Lesse, in the Semliki Forest, Belgian Congo, in March, 1914. A large *Achatina* that was crawling in the rain over decaying leaves had sixteen wingless flies, which were swiftly running over the mantle and under the shell of the snail, entering even the pulmonary cavity. They were accompanied by two unidentified mites and a single, minute, slender larva of some unknown beetle. *Wandolleckia* differs widely from the usual type of fly, looking much more like a flea or a mite. Wings, halteres, and ocelli are lacking; the eyes are very small, reduced to about thirty hemispherical ommatidia; the legs are long and slender. At least the species *W. biformis* is dimorphic. The largest individuals, about 2 mm. long, are physogastric, the abdomen being much swollen and dirty yellow, while head and thorax are dark chocolate brown. Stenogastric specimens are but 1.1 mm. long, uniformly pale yellow, with depressed abdomen. As both kinds of individuals are females and as their morphological structure is the same, dimorphism is evidently due to further development of the body during the adult or imaginal stage, a most unusual feature among insects. It is known also for the females of certain Puliciphora and Termitoxenia among the Phoridae, and for the females of termites and of certain parasitic Formicidae. In the case of *Wandolleckia* the

increase of the abdomen results from the hypertrophy of the reproductive organs, probably in connection with some ethological peculiarity. Unfortunately the reproductive habits, the early stages, and the males are still unknown. Another point to be elucidated is the food of these tiny flies. They are, it seems, perfectly harmless to the host and it is quite possible that they merely feed on the slimy excretion of the mantle (J. Bequaert, in Pilsbry, 1919: 61-63).

(3) Parasitoids. Many insects feed in the early stages upon other, living organisms which they eventually kill. They are generally spoken of as "parasites," but they are more properly called "parasitoids," as O. M. Reuter and W. M. Wheeler have pointed out. They are really, as Wheeler (1923: 46) expresses it, "extremely economical predators, because they eventually kill their victims, but before doing so spare them as much as possible in order that they may continue to feed and grow and thus yield fresh nutriment just as it is needed." *Melinda cognata* (Meigen), one of the Calliphoridae, is a true, specific parasitoid of terrestrial snails in Europe, where its life history has been worked out by Schmitz (1917) and Keilin (1919). The eggs are laid in the mantle cavity of living Helicidae. Upon hatching, the young larva bores into the kidney where it lies with its posterior end, bearing the spiracles, protruding into the mantle cavity. Later the larva, having destroyed the kidney, devours the liver and finally attacks all the other organs of its victim. About that time the snail dies and shortly afterward the full-grown larva leaves the shell, digs in the soil, where it becomes a puparium from which the adult fly emerges about a fortnight later. It is extremely probable that several of the other flies bred from mollusks are specific parasitoids. This is quite likely the case in Europe with *Sarcophaga filia* (Rondani), *S. melanura* Meigen, and *S. soror* Rondani, as well as with some of the Sciomyzidae. There is no fly known in America, nor indeed outside Europe, that unquestionably is a specific parasitoid of snails.

No Diptera had thus far been obtained from any South American mollusk. I was therefore particularly pleased to find at Pará, Brazil, two snails each containing a dipterous puparium. The adult flies were bred a few days later and proved to belong to the Sarcophagidae. They appear, however, to be so different from the other members of the family, that both genus and species are described as new.

#### MALACOPHAGULA, GEN. NOV.

Head (Fig. 1a) rounded, the front and epistoma not protuberant. Outer vertical bristle absent; no fronto-orbitals. Antennae very short, reaching but little below the middle of the antennal groove; second segment unusually large, the third short and broad. Arista short plumose over a little more than the basal third; the apical portion bare.



Palpi slender. Eyes bare. Thorax with four notopleurals and two sternopleurals; hypopleurals well developed; postscutellum absent. Abdomen depressed dorsally; no discal bristles; marginals present on the sides of first, second, and third, and on entire width of fourth tergites. First posterior cell of wing (Fig. 1*b*) closed far from the margin; fourth vein bent at right angle and with long appendage; first and fifth veins bare; basal portion of third vein bristly. Pilosity of

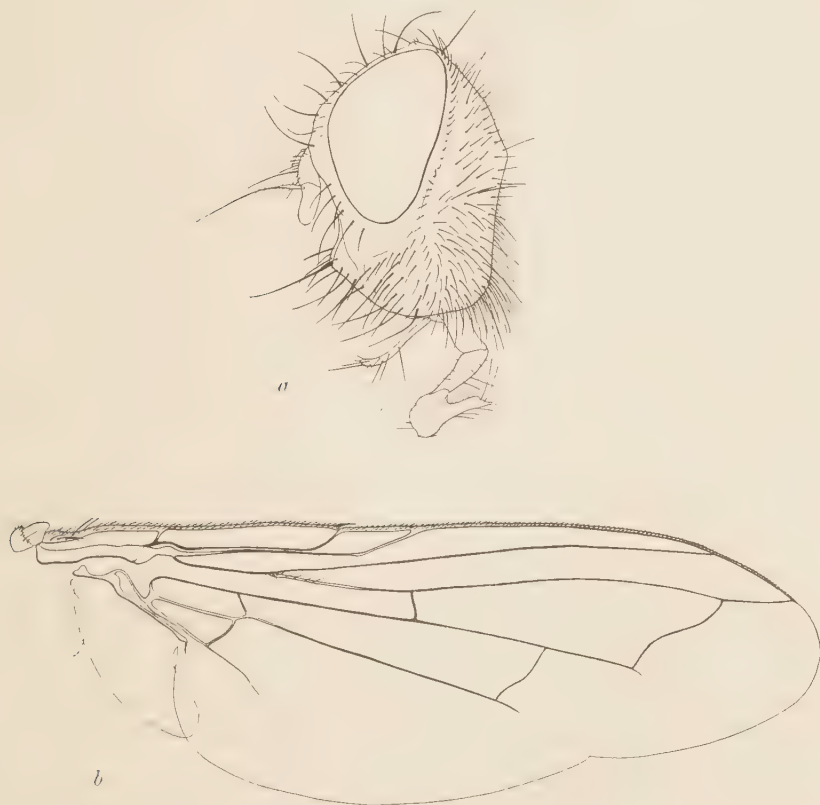


Fig. 1.—*Malacophagula neotropica* J. Bequaert. Female: *a*, head; *b*, wing.

legs normal. Coloration of the usual *Sarcophaga* type, pollinose, with tessellate spots. The chaetotaxy is detailed in the description of the genotype.

Type: *Malacophagula neotropica*, sp. nov.

Although possessing the general appearance and the essential characters of the *Sarcophagidae*, this insect appears to be quite distinct from any of the genera described in that family. The shape of the antennae, the long-petiolate first posterior cell, and the flattened abdomen should

render its recognition easy. Mr. J. M. Aldrich, who kindly examined one of the specimens, writes me that the species does not exist at the U. S. National Museum.

*Malacophagula neotropica*, sp. nov.

Type female, bred from the snail *Bulimulus tenuissimus* (d'Orbigny), obtained at Belem, Pará, Brazil, on September 20, 1924; collection of the Museum of Comparative Zoölogy, Cambridge. Paratype female from same host and locality; collection of the U. S. National Museum.

A small, grayish fly, with tessellate, black spots and bands and much flattened abdomen.

Female.—Head (Fig. 1a) rounded, the front and epistoma not protuberant; cheeks (bucca of Aldrich) swollen and long, reaching in profile more than one-half of the greatest diameter of the eye; metacephalon not divided off from the bucca. Front about one-fourth of width of head at vertex, considerably widened below, occupying over one-third of the head at the base of the antennae. Frontal stripe shiny black, rippled, below the ocelli about as wide as parafrontals, twice as wide at insertion of antennae. One pair of small ocellar bristles; one postvertical; outer vertical absent, the inner vertical very strong; 7 frontals, some of them quite feeble, forming a row strongly divergent below, where it reaches to about the insertion of the antennae; no fronto-orbitals, but their place seemingly taken by a row of fine hairs; parafacial with a row of 4 to 6 strong and feeble macrochaetae; vibrissae normally apart, on the oral margin, much below the lower edge of the eyes. Facial ridges bare, except for a minute group of 3 stiff hairs in the extreme lower portion, immediately above the vibrissae. Bucca and occipital region with many small, stiff hairs, but no soft pile; behind the eye, some distance from the outer orbit, there is a regular row of some 20 stiff, postocular bristles. Antennae very short, reaching but little below the middle of the antennal groove; first segment with short setae; second segment unusually large, about as long as the third, anteriorly with many stiff, short hairs, and a long bristle placed much before the apex; third segment short and wide, but little longer than broad, with straight upper edge and broadly curved lower margin, the apex being bluntly oblique. Arista longer than the antenna, very thin apically, rather abruptly thickened in the basal fourth; short plumose over a little more than the basal third; the apical portion bare. Palpi slender, slightly thicker in their apical half, where they bear many long, black bristles. Head black; ptilinum pale brown; integument mostly covered with silvery and somewhat silky bloom, which is especially marked on parafrontals and parafacials; hairs generally black, those on the metacephalon whitish; antenna pale

reddish brown, the third segment infuscated in its apical half; proboscis black; palpi straw-colored, somewhat reddish.

Chaetotaxy of the thorax: 3 humerals, the anterior one small; 2 posthumerals, the anterior one small; 2 presuturals, the innermost very small; anterior acrostichals not distinguishable from the hairs; 4 anterior dorsocentrals; 4 notopleurals, the anterior one quite small, the second and fourth prominent, the third shorter than its neighbors; 3 posterior dorsocentrals; no posterior acrostichals, but a small pre-scutellar present; 3 supraalars, the middle one much the longest; 2 intraalars; 2 postalars; 2 marginals on the scutellum, which has one small subapical, but no apical; on the sides there are 6 strong hypopleurals in one row; 2 sternopleurals, placed 1:1; 3 propleurals; and 7 or 8 mesopleurals, of which 4 only are well developed. Thorax black, covered with grayish white bloom, which has a somewhat yellowish tinge in the humeral region; in the proper light the dorsum shows three longitudinal, black stripes of about equal width, the median one faintly continued on the scutellum; they are separated by about equally wide, gray bands; there is a narrower and fainter black stripe above the base of the wing.

Legs of normal size and shape. All tibiae straight, shorter than the corresponding femora. Soft pilosity sparse and inconspicuous; a little denser and longer on the under side of hind tibiae. Anterior femora with one row of moderately long, stiff hairs along the upper edge and a conspicuous, comb-like row of long bristles along the lower edge. Anterior tibiae with four bristles at the tip; one on the hind face in about the apical third; three along the upper edge, one of which is placed slightly beyond the middle, while the two others are smaller and about midway to the base. Middle femora with a double row of rather short bristles along the lower edge, one of the rows placed anteriorly, the other posteriorly; in addition the anterior face bears one bristle about the middle, while the posterior face has an oblique pair of macrochaetae shortly before the apex. Middle tibiae with 8 bristles at the tip, three of which are much longer than the others; about the apical third there are four strong bristles forming more or less a circle around the tibiae and two more near the middle of the length, one placed anteriorly, the other posteriorly. Hind femora with a row of short bristles along the upper and lower edge; an additional, smaller row on the anterior (outer) face; and one long, preapical bristle on the posterior face. Hind tibiae with seven apical bristles, of which four are quite small; in addition the upper edge, the anterior face, and the posterior face each bear two long bristles quite far apart from each other. Legs black, with faint grayish bloom; the soft hairs and stiff bristles black.

Abdomen distinctly depressed, the dorsal face being unusually flattened. There are no discal bristles; marginals are found in the extreme corners only of first, second, and third tergites (two on each side, of which the innermost is much the strongest); the first tergite bears in addition one strong lateral bristle amidst some weaker, long hairs; fourth tergite with a complete row of eight marginals (four on each side). Abdomen black, the apical segment somewhat reddish brown; a silvery white bloom covers most of the first and second tergites and the middle of the third tergite, as well as the ventral side; the bloom is more golden yellow on the fourth tergite and on the sides of the third; in the proper light, black spots form a continuous, median, longitudinal band on the dorsal face; there are additional, ill-defined and vanishing black spots on the sides toward the apical margin of the tergites.

Wing (Fig. 1b): first and fifth longitudinal veins bare; basal portion of the third with a row of six or seven stiff hairs, reaching not quite half-way the anterior cross-vein; first posterior (apical) cell closed far from the margin of the wing, the petiole reaching in length over two-thirds of the fifth costal segment (between tips of second and third veins) and ending before the apex of the wing; fourth vein bent at right angle and with distinct appendage; the apical cross-vein bisinuate. Base of third vein with two strong bristles on the under side of the wing. A short costal spine; the swollen base of the costa with several rows of bristles, some of which are very long; basicosta (subepaulet) bare; epaulet with short, black bristles. Upper and lower squamae bare on both sides; upper squama finely fringed with white hairs; the margin of the lower squama with extremely short pilosity. Wings hyaline with clove brown to black veins; the base of the costa yellowish brown; basicosta yellowish white; epaulet clove brown; squamae milky white.

Total length, 7 mm.; width of abdomen, 2.2 mm.; length of wing, 5.5 mm.; width of wing, 2 mm.

On September 20, 1924, while walking in the public garden of the Praça da Republica, at Belem, Pará, about 8 a. m., I noticed many living specimens of the snail *Bulimulus tenuissimus* (d'Orbigny), attached to the low grass and weeds. The animals were drawn back in the shell, being evidently ready to rest during the hot hours of the day. Upon collecting a number of them, I noticed some that were fixed upon a pole and among these two apparently half-grown, empty shells. They were placed about five feet from the ground amidst living specimens and seemed to be in quite fresh condition. They no longer contained an animal, but in each of them one could see through the shell, in one of the whorls, a pale brownish body which appeared to be a dipterous puparium. Upon attempting to remove these shells, it was



found that the aperture was quite tightly cemented with dirt to the support, so that the entrance to the shell was completely closed. Careful search failed to disclose other infected specimens, and among a hundred or more living snails collected none were found to harbor a larva. From the puparia in the infected snails two female flies issued, on September 26 and 28.

The empty puparium is of a light reddish brown color, about 11 mm. long and 3 mm. wide. It is placed inside the shell about two-thirds of a whorl from the aperture and is closely attached to the outer curve, where it occupies in width the lower two-thirds of a whorl. In length it extends from about the middle of the penultimate whorl to the first third of the last. This mode of pupation inside the shell is similar to that described by Lundbeck (1923) for the Sciomyzidae of European fresh-water snails.

Although I have failed to find the larva in living snails, I believe I am justified in regarding this sarcophagid as a true parasitoid, and not as a scavenger. I base this conclusion upon the following evidence: the empty shells look quite fresh and glossy and are not in the least weathered, so that the snails, when found, could only have died quite recently; they were not found lying about loose, but were attached several feet above the ground to a pole, among healthy, live snails; the aperture was solidly cemented to, and tightly closed on, the support, exactly as estivating snails fix themselves in tropical regions to the bark of trees. Conditions were the same for both infected shells. All this could hardly be accounted for if the dipterous larvae had merely attacked dead or decaying snails.

The material was obtained during a recent trip to the Amazon as a member of the Third Hamilton Rice Expedition, in conjunction with the Department of Tropical Medicine of Harvard Medical School. I owe the identification of the snail to Dr. H. A. Pilsbry, of the Academy of Natural Sciences at Philadelphia, whom I wish to thank here for his cordial help.

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# THE MORPHOLOGY OF *MASTIGINA HYLAE* (FRENZEL) FROM THE INTESTINE OF THE TADPOLE

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This species was first reported from Argentina by Frenzel (1892) who found it in the posterior intestine of a tadpole belonging to the species *Hyla pulchella*. He named it *Tricholimax hylae* but R. Goldschmidt later placed it in the genus *Mastigina* Frenzel. Collin (1913) published an account of the cytology of the free and cyst forms from the tadpoles of the European species *Bufo clamita* and *Alytes* sp? The writer has found the same protozoon in the posterior intestine of the tadpoles of *Rana clamata* and *R. catesbiana* taken from a little pond on the Princeton University campus.

The incidence of infection is rather high. A record of fifty tadpoles examined during October, 1923, showed that that seventy-four per cent. were infected with *Mastigina hylae*. Out of one hundred large

TABLE 1.—Measurements of Ten Individuals from a Fresh Smear

Body		Nucleus		Karyosome	
Length	Width	Length	Width	Length	Width
115.2	43.2	14.4	14.4	5.6	6.0
110.4	30.4	10.1	9.2	4.6	4.6
135.0	23.0	9.2	9.2	4.6	4.6
92.0	21.2	9.2	7.3	3.7	5.5
129.1	23.0	10.0	10.0	7.0	7.0
88.3	29.2	8.3	8.3	3.6	3.6
148.1	30.0	12.0	14.0	6.0	5.8
50.0	21.0	8.2	7.9	4.4	4.0
78.5	28.3	7.4	8.3	6.0	6.2
101.2	31.5	11.0	13.5	5.5	5.5
Average	104.8	10.0	10.2	5.1	5.3

bullfrog tadpoles pickled during the summer of 1919, forty-eight were found to have this protozoon in their intestine. The fluid between the wall and fecal mass of the posterior part of the intestine is the locus where these organisms live as harmless commensals, feeding upon various green plants present in great numbers in this region.

Although hundred of tadpoles were examined during the months of October, November and December of the last two years, the writer has been unable to find the dividing and encysted forms which Collin found in such great numbers. Very nearly all the individual organisms were in the trophic or free stage with one resting nucleus, although a very few were binucleated. Collin rarely encountered uninucleated forms.

Morphologically this protozoon shows close enough affinities to the other members of the genus *Mastigina* to make it a natural member of this group. The body is essentially that of an elongated monopodal amoeba. The anterior end is rounded and does not change its shape. The nucleus can easily be seen in the clear hyaline anterior end. On the periphery of the cell to one side of the nucleus can be seen with difficulty in a living specimen a small flagellum which shows no active movements. It vibrates passively from the movements within the cell due to active protoplasmic streaming. Frenzel made the same observation. At the posterior end of the cell is a tail-piece or uroid, by which it may attach itself to the substratum and to which particles of intestinal debris may stick. From the uroid short blunt pseudopodia often are projected. The cytoplasm is clear and is generally filled with food vacuoles containing ingested green cells or fragments of cells.

Smears of the intestinal contents were fixed in hot Schaudinn's fluid and stained by the iron-hematoxylin method in order to make out the finer cytological details. It was found out by experience that if the coverglass was dropped onto the fixing fluid too soon after the smear was made, the organisms would round up so that the anterior end could be studied only with the greatest difficulty (Figs. 2, 3). A few minutes should elapse between making and fixing the smear so that streaming of the protoplasm may be resumed and the anterior end extended free from the food particles in the cytoplasm.

The nucleus at the anterior end and its large refractile karyosome can easily be seen in the living unstained conditions (Fig. 11). Stained preparations show a nucleus with a pronounced achromatic membrane and a large deeply-stained karyosome. In most of the specimens the karyosome appears to be a solid chromatin mass (Figs. 1, 3, 4, 6, 9). In others it is more or less vacuolated (Figs. 2, 8, 10), while a few show a still more deeply-stained body inside the karyosome (Fig. 5). Between the karyosome and nuclear membrane is a zone filled by an achromatic network on which fine and coarse basophilic granules are suspended. The nucleus may be round, oval, or irregular in shape as shown in the figures. Measurements vary as indicated in Table 1.

A basal granule or blepharoplast which gives rise to a fine short flagellum lies outside and upon the nuclear membrane to one side of its anterior surface (Figs. 1, 5). It often appears to be rounded, but more often it is somewhat elongated (Figs. 3, 5). A deeply-staining curved slender rod arises near the distal end of the granule and extends posteriorly into the cytoplasm. Frenzel referred to this structure as the "ancré," but I shall call it the rhizostyle because of its resemblance and possible homology to similar structures in some entozoic flagellates. It seems wise to reject the term rhizoplast for a structure arising from a basal granule and ending free in the cytoplasm because it has so



often been applied to the thread-like connections between nuclear elements and basal granules and between basal granules.

From the proximal end of the basal granule an interesting structure which Frenzel called a "cape" takes its origin. It appears from a lateral view to be a curved rod running along the anterior margin of the nucleus (Figs. 1, 4, 5). A view of the structure at right angles to those represented in these figures, however, shows that it is about as broad as it is long, and in reality is cup-shaped, with the concavity fitting over the anterior surface of the nucleus (Fig. 6). From all over the surface of this body great numbers of fine radiations pass through the clear intervening protoplasm to points on the rounded anterior periphery of the cell. The entire "cape" seems to fray out into these radiations at its margin. Apparently the whole structure itself is a compact bundle of these threads which radiate from it. Undoubtedly Collin did not realize the significance of the radiations, for he interpreted them as "une zone d'orientation cytoplasmique due á la traction du flagelle inséré sur le noyau." More probably the entire apparatus serves to anchor the nucleus securely to the gelled protoplasm at the anterior tip of the cell, for the flagellum does not vibrate.

The cytoplasm is coarsely alveolar in fixed and stained specimens and quite hyaline in the living condition. The body of the cell is generally densely filled with ingested food substances. Many of the particles are partially digested and unrecognizable, but filamentous algae, diatoms, desmids, green flagellates, and *Blastocystis* are often to be recognized. A large paramylum body of *Euglena oxyuris* may be seen in Figure 1. The process of food ingestion has never been observed, but it must be through the surface of the body, for no cytostome is present.

The protoplasmic streaming of this flagellated amoeba is essentially that which Rhumbler characterized as fountain streaming. There is an axial stream of protoplasm which flows swiftly and uniformly toward the anterior end, from which it is reflected back about itself as a hollow cylinder moving posteriorly when the animal is attached to the substratum by its uroid or suspended free in the water. The protoplasm of the outer cylinder returns to the axial stream at the posterior end just in front of the uroid (Fig. 11). The maximum amount of locomotion is of course attained when the entire ventral surface adheres to the substratum and the particles in the outer cylinder remain stationary with reference to fixed points on the slide. The essential features of the streaming were described in a previous note by the writer before the small inactive flagellum was seen (Becker, 1923).

The morphology of this *Mastigina* is especially interesting, for there is here a simple type of flagellar apparatus which corresponds closely with what one may consider was the primitive condition of various

entozoic flagellates; e. g., *Trichomonas* and *Chilomastix*. The basal granule or blepharoplast of this form is a unit and gives rise to one inactive flagellum. *Trichomonas* and *Chilomastix* have multiple blepharoplasts which give rise to from four to six active flagella. The rhizostyle arising from the basal granule finds its homology in the chromatic basal rod of *Trichomonas*, called the parabasal body by Kofoed and basal fibre by Dobell. In *Chilomastix* are two similar structures which Kofoed has designated the parabasal body and parastyle respectively, but which Dobell calls the right and left fibrils. The first structure resembles the rhizostyle of *Mastigina* even more than the second. Kofoed (1920) has pointed out how even so complex a flagellate as *Giardia* may be derived from a form like *Chilomastix*.

#### CONCLUSIONS

1. *Mastigina hylae*, an inhabitant of the posterior intestine of the tadpole, shows the following characters:

- a. An amoeba-like body and an amoeboid type of movement.
- b. A nucleus at the extreme anterior end.
- c. A basal granule situated on the nuclear membrane, from which arises, a short inactive flagellum, a rhizostyle, and a cape covering the anterior surface of the nucleus from which radiating threads are distributed to the periphery of the rounded anterior end of the cell.

2. The structure of this protozoon may serve as a ground plan for the morphology of other entozoic flagellates, such as *Trichomonas*, *Chilomastix*, and even *Giardia*.

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#### EXPLANATION OF PLATE

(All figures  $\times 1030$  except Fig. 4, which is  $\times 1780$ )

Fig. 1.—Stained specimen showing nucleus, flagellar apparatus, food inclusions, and uroid at posterior end.

Figs. 2 and 3.—Contracted condition, flagellar apparatus scarcely visible.

Fig. 4.—"Cape" pulled loose from the nucleus, due to fixation.

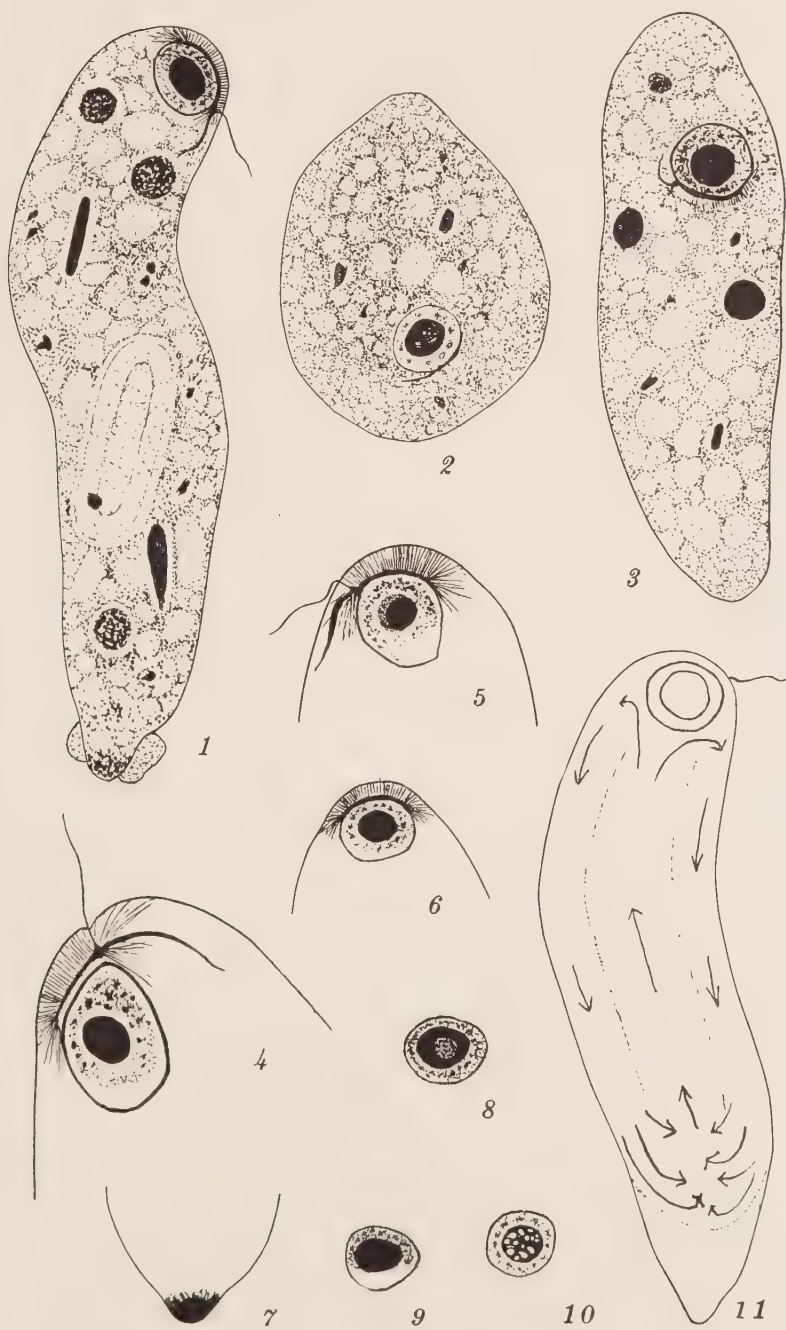
Fig. 5.—Anterior end showing normal arrangement of organelles.

Fig. 6.—View of "cape" at right angles to that in figure 5.

Fig. 7.—Deeply staining uroid.

Figs. 8, 9, 10.—Different types of nuclei found.

Fig. 11.—Diagram of a living specimen with arrows showing direction of streaming of protoplasm.







## SOCIETY PROCEEDINGS

### THE HELMINTHOLOGICAL SOCIETY OF WASHINGTON SEVENTY-SEVENTH TO EIGHTY-SECOND MEETING\*

The seventy-seventh meeting was held April 19, 1924. The following officers were elected: Dr. Cort, president; Dr. Schwartz, secretary; Miss Cram, corresponding secretary and treasurer.

Dr. Stiles placed on record a new case of *Diphyllobothrium latum* in man. The specimen was sent to the Hygienic Laboratory for diagnosis by H. S. Warner, Fort Stanton, New Mexico. Dr. Faust discussed *Diphyllobothrium mansonii* which was found in man and cats in China. He had not found *D. latum* in China.

Dr. Steiner presented a paper on the Host Problems of Nematodes; it was discussed in detail.

Dr. Hall presented the following note:

*Sarcocystis rileyi* from the domesticated duck. A duck purchased at the Center Market in Washington, D. C., was found by the purchaser to have numerous white spots in the muscles and was taken to the District Health Office and referred to the Zoological Division of the Bureau of Animal Industry on March 31, 1924; it was found heavily infested with *Sarcocystis rileyi* Stiles 1893. Crawley (1911) states that this species is by no means rare in mallards, shoveler ducks and domesticated ducks. In the collections and the check lists of the Bureau of Animal Industry there are records of this parasite from various duck hosts, including 'duck' and *Anas boschas*, but there appear to be no record from the domesticated duck or *Anas boschas domestica*. This record of a case from a duck marketed as a domesticated duck is of interest, not only as apparently the first record of the sort, but also as illustrating the possibility that the parasite might cause economic loss at times in some localities. On esthetic grounds, if for no other reason, the flesh of the duck in question would be adjudged as unfit to eat and it seems probable that where domesticated ducks were generally and heavily infested, an evident possibility, the loss to an individual duck-farmer might be considerable.

Dr. Cobb submitted the following comments on nemas:

1. A new mermithid infesting another Nema. *Nanomermis nemicola* n.g.

	5.	13.	29.	Juv.	92.8 (?)	
n.sp.	3.6	4.8	5.	5.4	3.	0.14 mm.

Anteriorly the neck becomes convexconoid, especially near the rounded, continuous head, which is a little more pointed than hemispherical. The spear of the typically mermithid pharynx is  $0.4\mu$  in diameter; but nevertheless possesses some stiffness and does not bend when the head is moved from side to side. There is evidence that the spear is protrusile. No definite lateral wings can be seen. Amphidial (?) markings occur a few microns behind the anterior extremity. Behind the pharynx the esophagus is about one-fourth, at the nerve ring about one-fourth, and at what appears to be the base of the esophagus about two-fifths, as wide as the corresponding portion of the neck. From just behind the nerve ring it increases gradually in diameter halfway to its base; then continues nearly cylindroid. Apparently there is glandular tissue from a little in front of the posterior end of the esophagus backward, pressing other tissues somewhat to one side. Whether there is more than one gland remains uncertain. Back-

\*The minutes of the 71st to the 76th meeting published in the December, 1924, number of the JOURNAL were erroneously numbered 70 to 75.

ward from this gland there extends a moniliform series of relatively large cells, each half as wide as the body and more than twice as long as wide, containing a few relatively large granules of variable size, the largest one-fifth as wide as the body. The portion of the body occupied by these cells is somewhat longer than all that precedes it, and extends to near the beginning of the posterior fourth of the body, where there is a decided change in internal structure, for there follow here, single file, six or seven trophocytes containing granules of two sizes, one large and evidently fatty in nature, and among them others  $0.2$  to  $0.5\mu$  across, probably proteid. The foremost one of these cells nearly always contains a minute birefringent crystal. No anus is to be seen. The terminus,  $2\mu$  across, is distinctly blunt and rounded. The position of the putative anus is perhaps indicated by cessation of the trophocytes at 92.8%. The body tapers regularly from behind the middle.

The parasite was found in the body cavity, mostly in the posterior part, of both sexes of *Mononchus subtennis* at Falls Church, Va., March and later, 1924 and 1925. Of 95 mononchs 11.6% were infested. Usually only one or two *Nanomermis* occur in each host; but in one mononch there were four, in another six, in another ten or twelve. Five other species of mononchs from the same locality were examined without observing this parasite; it is therefore not unlikely that it is specific to *Mononchus subtennis*.

The outstanding features of this interesting parasite are: 1. its excessively small size; 2. relative coarseness of the striation, and the crenate contour; 3. the small number of trophocytes; 4. the small number of the urocytes (?), probably four, and if so, recalling *Tetradonema*; 5. amphids (?) behind the cephalic papillae; 6. the rounded tail end (See Jour. Parasit., 11: 120).

2. Deceptive artificial light. The following instance shows the care necessary in judging color under the microscope when artificial light is used. An oncholaim, a marine nema, living on a bank distinctly colored by a growth of the microorganism, *Microcystis rosco-persicina*, became intra-vitam stained, owing to the presence of these organisms in its food. While this intra-vitam stain was very obvious when the nema was examined with the aid of an apochromatic condenser and objective, using sunlight reflected from a white-washed screen, there was not a trace of it to be seen when the same microscope was used with artificial light consisting of a strongly illuminated condensed filament in a hundred-watt bulb, the light being first passed through a piece of quarter inch daylight glass. Using this artificial light one would never have suspected, even remotely, that the intestine of the nema was strongly stained, in some parts a distinct claret color.

3. *Rhabditis icosiensis*, injurious in dewooling sheepskins; with observations on the male copulatory organs of this nema. Sometimes when sheepskins are dewooled by the old fashioned, aqueous, sweating process, circular pitted markings, found in the skins after the sweating, reveal the presence of nematodes. These pitted markings constitute a damage to the skin. An examination of some of these nemas, submitted by Dr. F. A. Mason, Director of the Bureau of Biotechnology, Leeds, England, showed rhabdites, by far the most common species being *Rhabditis icosiensis* Maupas. It is understood that these rhabdites and their relationship to the technology of sweating and tanning of sheepskins is being further studied at the Bureau of Biotechnology at Leeds.

The pair of large glands emptying into the vas deferens near the cloaca first noticed by Schneider in *R. strongyloides*, are constructed as follows: Proximally, these are three-celled glands; these three cells stain light purple with acid carmine. The number of the cells is indicated by the nuclei, which are here clearly to be seen though invisible in life on account of other contents of the cells. The cell walls are distinct; the main content of the living cells disappears under the treatment, so that the cells after mounting in balsam appear as if nearly vacant. The cells empty backward and are connected with a duct having a granular content. Alongside the duct are about three strongly

staining cells (acid carmine) arranged tandem and having distinct nuclei. This region is that which is yellowish in the live specimen. Behind these latter cells the gland is granular and continues so until it joins its mate; they then have a broad common duct for a short distance which empties into the cloaca or vas deferens. At the junction of the two glands there are two glands there are two nuclei, one to each duct, lying near the angle of confluence. These glands evidently supply the secretion, often yellow, seen at the time of copulation, which appears to act as a cementing medium and may also serve other purposes, e.g., aseptic.

With regard to the cellular structure of the tail behind the anus and thereabouts, there seem to be no nuclei in this portion of the tail except those of nerve cells. Without doubt the ribs of the bursa are connected directly with these nuclei. The number of nuclei is in accord with the number of ribs of the bursa. Although there are more nuclei than there are ribs, the excess is so located as to indicate clearly that they are connected with anal structures, not bursal. These nuclei are so arranged that they might be regarded as a double caudal ganglion; they are, at any rate, more or less distinctly paired and the number of nuclei is the same on either side of the dorso-ventral plane. There are no other cells (e.g. glandular) in any part of the tail that could be assigned as definitely connected with the bursa. This leads to the conclusion that the ribs of the bursa, in this case at any rate, are probably mainly sense organs.

C. W. STILES, *Secretary*.

The seventy-eighth meeting was held May 17, 1924. Mr. Sellers reported two cases of *Hymenolepis diminuta* in children in Georgia. In both cases diagnoses were based on finding hexacanth embryos in feces. In one case the child was treated with male fern and a 12 inch specimen of *Hymenolepis diminuta* was recovered. The second case which was from Decatur County could not be followed up. In the discussion Dr. Hall called attention to the fact that Sturdevant reported a specimen of *H. diminuta* 1.5 m. long before fixation and 99 cm. long after. The specimen in question was from a rat.

Miss Cram reported on a female specimen of *Cylicostomum ultrajectintm* to which two males were attached and called attention to a similar case in *Cyathostoma bronchialis*. Miss Cram also reported the attachment of *Ancylostoma caninum* to *Taenia* and to *Dipylidium*; this condition was observed at the autopsy of a dog. In the discussion, Dr. Schwartz stated that he saw on one occasion two males of *Necator americanus* attached to one female, an observation made in the Philippines on specimens obtained from man, following anthelmintic treatment. He also pointed out that hookworms and other strongyles frequently attach themselves to pieces of tissue in vitro at room temperature. Dr. Hall stated that Dr. Shillinger made the observation that hookworms which become attached to various objects at room temperature detach themselves in an incubator.

Dr. Cobb presented the following note:

A study of the development of the larvae in utero of *Rhabditis icosiensis* Maupas discloses an interesting correlation between the intestinal cells and those of the genital mass. When the larvae have reached their maximum development inside the eggs, four intestinal cells behind the genital mass and two in front of it contain the birefringents characteristic of the intestinal cells of this species. This relationship of the intestinal cells to the genital mass at this particular stage of the development of the larva is definite and invariable, as ascertained from the examination of a large number of specimens. The two intestinal cells immediately opposite the mass, however, do not contain the birefringents. As soon as the larva has escaped from the egg and begins to take nourishment from outside, the birefringents become deposited in the other cells of the intestine (Fig. A).

The renette system of *Rhabditis icosiensis* is shown (Fig. B). In general it is of the form frequently figured in the literature as common in the genus

Rhabditis. Connected with the system are two renette cells as shown in the figure. At an earlier stage (Fig. A) of a larva removed artificially from the egg taken from the uterus, the renette system has advanced only to the stage where a single cell is connected with it and the ducts, instead of lying in the lateral chord, lie ventrad of the lateral chord. This seems to indicate the derivation of a double renette system in the adult from a single mass as previously observed in the *Oxyuris* of man and of the mouse.

Dr. Stiles presented two cases of spurious parasitism in man:

1. The material in question, said to have been vomited by a boy in North Carolina, was forwarded to Washington for determination. After studying



Figure A



Figure B

Fig. A. Recently hatched larva of *Rhabditis icosiensis* Maupas. Six intestinal cells opposite the gonad (*gon*) alone at this age bear birefringents, (*grn birf*).

Fig. B. Renette of *Rhabditis icosiensis*; anterior and posterior ducts shown in part.

the material Dr. Stiles risked the opinion that it was a portion of a placenta of some animal but this view was received with ridicule by Dr. Stiles himself as well as by his associates. The specimen was then forwarded to Dr. W. H. Welch at Johns Hopkins University who determined it to be a portion of the placenta of a cat. Dr. Stiles stated that this was the most remarkable object that was ever mistaken for a parasite.



2. This specimen originated in New Mexico in a man who was thought to be tubercular. Sections of the material showed plant fibers and casts. It was finally determined to be a bronchial cast.

Dr. Schwartz reported the occurrence of *Capillaria plica* in the United States. According to the records of the Zoological Division of the Bureau of Animal Industry this parasite has been found in the urinary bladder of a dog from Bethesda, Md., the determination having been made by Dr. Ransom in February, 1923. In March, 1924, specimens of *Capillaria plica* were found by Dr. Hall and Dr. Schwartz independently in the urinary bladders of several black foxes (*Vulpes fulva*) that were shipped from New Jersey to the Bureau of Animal Industry for post-mortem examination. Dr. Schwartz stated that he had failed to find specimens in the kidney but that Dr. Hall found one specimen in the pelvis of the kidney.

Dr. Faust called the Society's attention to the untimely death of Dr. Nelson Annandale, late Director of the Zoological Survey of India, who had collaborated with him and Dr. Meleney in their studies on schistosomiasis in China.

The seventy-ninth meeting was held September 20, 1924. Dr. Steiner exhibited a drawing of the tail end and the spicula of a species of Hexameris, the spicula being of unusual length (8.06 mm.) and structure. The proximal ends are free, but a short distance caudad join each other and are twisted together apparently in a right-handed spiral for a distance of about 1.4 mm.; they then run parallel for about 1.134 mm. and are twisted again, but now apparently in a left-handed spiral. At the distal end they are again parallel and amalgamated. This case seems to suggest the possibility that the change from paired spicula to a single spiculum may take place not only by the obliteration of one spiculum but also by amalgamation. Unfortunately the structure of the female sex apparatus could not be made out, so that a correspondence of the length and structure of the spicula with it could not be ascertained. The European *Hexameris elegans* (Hagmeier) shows similar spicula but only 1.5 to 1.8 mm. in length.

Mr. Sandground presented a note on Spurious cases of Strongyloides due to *Rhabditis hominis*.

Dr. Shillinger reported a recent observation on a female of *Ancylostoma caninum* to which two males were attached.

Dr. Hall presented the following note:

Cuterebrid larvae in cats and dogs.—Cuterebrids are normally parasitic in rodents, rabbits and hares. They occur occasionally in dogs and cats. In previous papers the writer has summarized the records from cats, the records showing a total of over 14 cases. A specimen recently sent in by Dr. H. J. Milks from Ithaca, New York, and a record of a case at Wheaton, Illinois, observed by Dr. Harry Caldwell and reported to the Zoological Division by Dr. H. B. Raffensperger, make a total of 16 definitely recorded cases, with evidence in the form of reports stated in general terms to show that quite a number of additional cases have been observed. Up to the present time only 2 cases have been reported in dogs, the reports being by French in Canada and Crawley in Pennsylvania. A specimen sent by Dr. Harry Caldwell to Dr. Raffensperger and by the latter to the Zoological Division constitutes a third case. In addition Dr. J. V. Lacroix has told the writer that he has had at least 4 such cases at Evanston, Illinois, making a total of at least 7 cases from dogs.

Dr. Cobb presented a note by Dr. G. A. MacCallum in which the writer stated that he had observed on the under white surface of the nose of the shark, *Carcharhinus commersonii*, a very delicate and pretty tracing—as if drawn with a fine pen and black ink. He took some pieces of the tracing, which

was about  $2\frac{1}{2}'' \times 1\frac{1}{2}''$ , and on placing them under the microscope found them to consist of black nematode eggs in the narrow grooves between the scales, which were it not for the presence of the eggs would be almost invisible to the naked eye. He expressed the opinion that the habitat of the worms is in the nasal gland and that they go from there into the cutaneous tissues where they could burrow about. He also found these eggs upon the skin of the whiter portions of the anterior fins of another shark of the same species. I am of the opinion that the eggs are those of some species of *Capillaria* or a closely related form. They measure 0.10 mm. by 0.05 mm., and the diameter of the polar projections is 0.02 mm.

Dr. Cobb presented the following notes:

A case has been observed in which the cavities of externally connected repetitive organs in the lateral chords, homologous with lateral organs known in a variety of genera of nemas, are connected up with each other, and carry a fluid which is at liberty to move from one organ to another. This is believed to make it probable that in other cases where similar lateral organs exist, as they are known to do, (*Plectus*, *Rhabditis*, *Cyatholaimus*, *Thoracostoma* and many others), they are connected up with each other internally but that the connection has not been observed. Should this belief prove well founded, it would definitely add to the nema anatomy a separate system of intercommunicating organs in the lateral position, and may prove important in settling phylogenetic relationships.

A further examination has been made of the external tubular organs of nemas (a number of them sensory) which appear to have developed from ordinary setae, and on the basis of this further study separate names are proposed for them, the use of which will add precision to discussions of these organs: axids for those with an axial nerve whose terminal is near the distal end of the organ; porids for butular setae serving as outlets for glands, and sometimes serving for locomotion, as in *Draconema*.

The number of nemas in which it is known that the cells of the intestine are of varied character has been increased, and it has been made probable that in all cases whatsoever the intestinal cells of free living nemas are much differentiated; that they are divided into groups which perform a considerable variety of function, comparable, indeed, in some ways, with the variety of function discharged by the different organs accessory to the alimentary canal of the most highly organized animals. The number of nemas known to have jointed setae has been increased, and the probability very much increased that the setae of nemas are normally jointed. The amphids have been seen definitely connected with the central nervous system in a considerable additional number of species belonging to a variety of genera. Hitherto this had only been done with a greater or less degree of certainty in two cases.

The reason for the heavy cuticularization of the amphids often observable on free living nemas had been made plainer by the discovery of a species in which the small, nearly circular, amphids, have, no doubt through evolution, been moved back to the middle of the neck. This is the case in a beach inhabiting nema having the habit of coiling itself into a ball, in order to protect its head and tail ends while being washed back and forth by the breakers along with the beach sand in which it lives. A reasonable explanation of the position of the amphids in this case is that it is necessary for them to be always in contact with the environment (moving water and sand) and in this case it is evident that this contact is of such a nature that the strengthening of the amphid by cuticularization is explained thereby.

The storage of birefringent matter as food has been demonstrated in *Sphaerolaimus*: and the use of the stored food matter in connection with reproduction followed, and proved to be like that of some of the *Rhabditi*. In *Sphaerolaimus*, both in the male and in the female, when the sexual organs begin to function, the birefringent stored-up food matter, which exists in the intestinal cells

in great quantities, is used up during the process of reproduction, and used first from those portions of the intestine next the gonads.

Additional species have been discovered in which the spermatocytes are produced in single file in the testis, and in which it is possible to study the history of the spermatocytes with greater accuracy than has hitherto been possible. The formation of bodies homologous with the polar bodies of eggs has been investigated, and their absorption studied by the aid of intra-vitam staining.

Greater clarity has been obtained concerning the distribution of the nerves in the anterior portion of the nema body; the sensory nerves and ganglia are those lying next to the esophagus in the body cavity, while the motor nerves pass along the walls next to the attachment of the musculature, somatic and esophageal. The theory proposed by the writer, that the cuticularized structures of the pharynx can be separated into two groups, one of which is ontogenetically more closely associated with the external covering of the body, and the other, more closely associated with the triquetrous lining of the esophagus, and originating farther back, seems to be supported by the discovery of a considerable number of species, mostly belonging to new genera, in which the pharynx is lined with denticles more or less easily homologized with structures of the external cuticula.

It has been shown that the form of certain amphids, e. g., spiral amphids, facilitates the movement of water in their grooves when they are moved in the direction of the dorsal ventral plane of the nema, this being the normal direction of their motion. The flow of water thus facilitated along their grooves would appear to tend to increase their efficiency as sense organs depending upon contact with the fluid medium the nemas normally inhabit.

The manner in which the nerve endings are distributed from the sensilla to a spiral amphid has been approximately determined: distribution along the spiral. That the right amphid is a left handed spiral, and the left amphid a right handed spiral, and that amphids in general are arranged on this plan, is in harmony with, and probably in part explained by, the fact that the dorso-ventral movement of the nemas makes it necessary for them to be formed in this way in order to prevent rotation of the nema during locomotion. It might, of course, also be said that this would be the natural tendency in the development of a bilaterally symmetrical animal, regardless of this fact.

Dr. Cobb also reported that he examined mud from lobster holes at Woods Hole, Massachusetts, and found 57 species of nematodes, representing 10 genera. All but two species appear to be new.

The eightieth meeting was held October 18, 1924. Drs. Pryor and Ewing were elected members of the Society.

Dr. Pfender presented a note bearing on the diagnosis of ascariasis by X-rays. An interesting case of a girl, aged 19, who had complained of vague pains in the right lower quadrant for several weeks, was referred to him for a roentgenological study of the gastro-intestinal tract. The examination was negative with the exception of the diagnosis of retro-cecal chronic appendicitis based on definite shadows and pain points. Operation showed the appendix adherent and fibrous. It was removed. Manipulation of the folds of the intestines revealed a distinct body in the ascending colon, about 10 to 12 cm. long, and the size of a lead pencil. This was apparently an *Ascaris*. The patient made a good recovery and ceased to complain of any further pain. About two weeks later the hospital interne administered an ascaricide with the result that two specimens of *Ascaris lumbricoides* were expelled. It is very difficult to conclude that the chronic appendicitis was directly associated with the worms in the intestinal tract.

In the discussion of Dr. Pfender's paper Dr. Hall called attention to the fact that several reports bearing on the diagnosis of *Ascaris*, *Cysticercus*

*cellulosae* and *Echinococcus* by X-ray examination have been published within recent years.

Dr. Steiner presented the following note:

*Eomermis meissneri*, a new Mermithid, is an interesting form in that it forms what appears to be a kind of hitherto missing link between the Mermithids and other nemas. *Eomermis meissneri* has an esophagus as other nemas, although that organ is reduced. The esophagus has the shape of a comparatively short tube extending some distance behind the nerve ring and behind the cephalic end of the so-called fat body, and has a cellular tissue surrounding it. Caudad this esophagus is followed by a string of what seems to be a tissue of shrunken and reduced character, apparently connecting it with the fat body and seemingly representing the anterior part of the ancestral intestine. It seems therefore that the fat body of the Mermithids is not homologous with the entire intestine of other nemas, but only with a part of it. Dr. Cobb showed that there is a pronounced functional difference between the various regions of the normal nemic intestine and that at least in some species and at a certain stage a limited part of it is used for the storage of reserve material (birefringent bodies). These observations enable one to understand the fat body of the Mermithids. As shown in *Eomermis meissneri*, only a part of the ancestral intestine is seemingly transformed into the fat body and this part is apparently homologous with the storage cells of birefringent bodies of other nemas; thus the fat body is often composed of only a small number of huge polynucleate cells.

Compared with other Mermithids, *Eomermis meissneri* has a short esophagus and the so-called esophageal cells as developed in other forms have not yet appeared in this worm. This again raises the question as to the significance of both the long esophageal tube and the frequent occurrence of huge esophageal cells in other Mermithids. If *Eomermis meissneri*, as is thought, represents a primitive case of these structures, it seems that the phylogeny of the Mermithids brought an increase in the length of the esophageal tube, which sometimes extends even close to the tail end. But if this organ is functionless, it is difficult to understand such an increase in size (absolutely general within the family). The speaker therefore is inclined to see in the Mermithid esophagus not a functionless organ but a means for getting the food into the body. The Mermithids live in the body cavity of their hosts, and apparently feed on the blood. This blood does not represent highly complicated food material which must first be transformed by digestion into simpler building elements assimilable by the Mermithid. Since the Mermithids no longer have fully developed digestive organs, they seemingly can live on the blood of their hosts as if it were their own, e. g., the host blood can be directly assimilated by the various tissues of the Mermithid.

Within the hosts the Mermithids do not "swim" in blood, i. e., their entire, and often large, bodies are not immersed in it, since, in insects the blood quantity is rather small. The speaker therefore comes to the conclusion that the esophagus of the Mermithids is a means by which the parasite might have all its tissues in contact with the blood of the host. Perhaps the mouth opening of the Mermithids is placed near or at an opening of the circulatory system of the host. These points of view are also in accordance with the fact that during the parasitism no toxic effect is shown by the host. In regard to the Mermithid metabolism it seems to be similar to, if not completely identical with that of the host. It might seem that the Mermithid is like an organ of the host or is even placed in the category of a favored organ, since the parasite is able to get its food even at the expense of the sexual glands, which often do not develop, whereas the Mermithid grows. The speaker therefore sees in the enlarged Mermithid esophagus a kind of channel for bringing the assimilable host blood close to all tissues.

The esophageal channel has to be formed and has to grow. It is easy to see that the cells or the tissue building them must be more developed in



the Mermithids than in the other nemas. The absence of any large esophageal cell in *Eomermis meissneri* with its short and thin esophageal tube, and the presence of numerous middle sized, or a few large sized cells, or a single gigantic cell, in forms with a large elongated esophagus, points to the probability that these so-called esophageal cells of the Mermithids are formative cells of the esophageal tube.

Dr. Chapin exhibited specimens of a Rhabditis, similar to *R. coarctata* Leuck. The nematodes were in cysts attached to mites of the genus *Macrocheles*, collected from a mass of decaying fleshy fungi. Dr. Cort spoke of his experiences among parasitologists in Japan, noting the most active Japanese workers in this field and touching briefly upon the problems that they are investigating.

Dr. Schwartz reported *Cysticercus cellulosae* from a dog, the material originating in Tonkin, Indo-China.

Dr. Cobb presented the following note:

A rare nema, *Deontolaimus papillatus* de Man (Fig. C).—Cuticular wings begin near the middle of the neck and end on the tail, finding their main

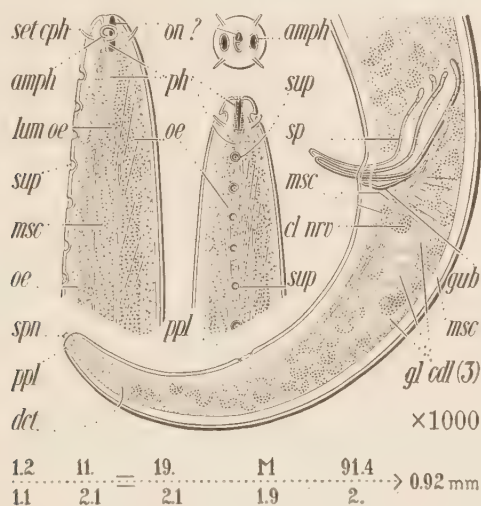


Fig. C. *Deontolaimus papillatus* de Man. Side, front and ventral views of head end and side view of the tail end of a male.

optical expression near the middle of the nema as two parallel refractive lines occupying a space a little over one-eighth as wide as the body, and interrupting the exceedingly fine, plain, transverse striae. Possibly there are three obscure lips. It is believed that minute obscure labial papillae rather closely surround the mouth. A narrow pharynx (*ph*) whose lining is distinctly more refractive than that of the esophagus, especially dorsad, extends three times as far back as the base of the amphids. Its dorsal element in the front half possibly has somewhat the character of a weakly developed onchium; there is at any rate a decided change from opposite the setae forward, in the form of a duplex dorsal affair (*on?*) apparently filling half the lumen; but whether free distally remains in doubt. The small hemispheroidal cardia is nearly one-third as wide as the base of the neck. The thick-walled intestine has an indistinct, somewhat zigzag, refractive lining. The intestinal cells, of such a size that possible only two are presented in each cross section, are closely packed with fine, very transparent, non-birefringent granules, not so disposed as to cause a tessellated effect; never-

theless the cell walls are so refractive that their limits are rather readily determined. The oblique nerve ring is accompanied, fore and aft, by rather clearly marked polyhedral nerve cells. While doubtful the number of the testes seems to be two. At a considerable distance from the cardia in the anterior part of the body there are two ellipsoidal organs (?), half as wide as the body, whose significance remains in doubt. Other features precisely as described and figured by de Man.\*

Habitat: Slightly brackish leaf-mould soil, Devil's Foot Island, Woods Hole, Mass., U. S. A., July 23, 1924. Hitherto known only from brackish sandy soil, Island of Walcheren, Holland. The present excellent specimen gives additional data as to (1) the amphids; (2) the vestibule and pharynx; (3) the caudal glands; (4) the supplements of the male; and (5) the testes. No female seen. *Deontolaimus* seems a not distant relative of *Aphanolaimus* and *Plectus*.

Relationships of (1) *Plectus*, (2) *Aphanolaimus*, (3) an Unpublished Genus and (4) *Deontolaimus*.—The preceding note leads to the suggestion that the above four genera form a series somewhat in the order named.

Males of the new, as yet unpublished, genus have preanal ventral supplements as in *Plectus* and *Aphanolaimus*, but they are continued forward to near the head by simpler, but homologous, organs devoid of the protrusile element. Should such a nemic form by evolution lose the posterior protrusile supplements, there would be left only an isolated anterior residual series, such as exists in *Deontolaimus*, where the cup-shaped organs (papillae of de Man) occur only on the neck. The other anatomical features of these four genera are such as independently to suggest phylogenetic relationship. *Deontolaimus* is not the only nemic genus with isolated ventral cervical supplements on the males; the homology of such organs has never before been discussed.

Miss Cram presented a note by Dr. Riley of the University of Minnesota, on nematodes causing a disease of ducks in Hong Kong. Specimens of these nematodes were submitted to the Zoological Division of the Bureau of Animal Industry and found by Dr. Chapin to be filarids, no specific determination being possible on account of the poor condition of the specimens.

The eighty-first meeting of the society was held November 22, 1924, at the School of Hygiene and Public Health at Baltimore, Md. Misses Spear and Orleman were elected members of the society.

Dr. Cleveland discussed his work on the protozoan parasites of termites.

Dr. Root spoke on differentiation of the larvae of species of *Anopheles*.

Dr. Barnes reported the results of a parasitological survey in Siam where 244,000 persons were examined for intestinal parasites. Fifty-seven per cent. were found to be infested with hookworms. Eleven hundred worm counts were made. The average number of hookworms expelled in the first seven hours after treatment was 37, and that number rose to 87, forty-eight hours after treatment. The maximum number of worms found in any one individual was 400. Dr. Barnes stated that on the whole, hookworm infestation in Siamese is not heavy. He also noted that the incidence of hookworm infestation in Siam increases in the direction away from the sea which he ascribed to the heavy floods in the lowlands, the larvae being killed in all probability, by the overflow from the rivers.

Dr Barnes stated that 26 per cent. of the persons examined were found to be infested with *Ascaris*, and noted that the incidence of infestation may be actually higher, since the persons who carried on the survey were primarily interested in discovering hookworm ova, those of *Ascaris* and other parasites being noted only incidentally. The speaker stated that he considered *Ascaris*

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\* "Die frei in der reinen Erde und im süßen Wasser lebenden Nematoden der niederländischen Fauna." 1884, p. 31, Taf. 1.

infestation to be a serious medical problem and noted the following pathological effects due to these worms based on his observations in Siam:

In heavy infestations the worms cause intestinal disturbances. In a two-year old emaciated child that expelled several hundred ascarids, no other parasites being present, a rapid recovery followed anthelmintic treatment. He noted that in nervous people the presence of *Ascaris* causes irritation that may precipitate convulsive attacks. He cited the case of a young man who had been completely incapacitated as a result of frequent convulsive attacks. Following removal of the worms he remained free from attacks for a period of two years during which he was available for observation. The speaker also stated that after removal of ascarids from epileptics the number of epileptic attacks had been found to decrease.

He reported a case of intestinal obstruction due to *Ascaris* in which perforation of the intestinal wall by the parasite led to a fatal termination. He also reported an abscess in the lumbar region of a young girl, 19 mature ascarids having been removed from the abscess. The abscess healed after the last worm was removed. The speaker expressed the opinion that the worms causing the abscess had probably migrated from the intestinal tract.

Dr. Barnes emphasized the spontaneous migrations of adult ascarids in diseased subjects, the migrations being especially pronounced two or three days before death. The speaker stated that the administration of drugs may stimulate *Ascaris* to unusual activity, and in this connection he cited the case of a child to whom castor oil and quinine had been administered. The child began to suffer from intense abdominal pain and became cyanotic. Death resulted from asphyxiation due to an *Ascaris* crawling into the trachea. He cautioned against the administration of anthelmintics in doses insufficient to stupefy or kill *Ascaris*. He stated that the administration of small doses of anthelmintics may cause *Ascarids* to tie themselves up in a knot thus producing acute obstruction, which may have to be relieved by surgical interference. He also noted that chloroform anesthesia may produce such consequences in subjects infested with *Ascaris*. He stated that in certain hospitals in Siam it is customary to remove *Ascaris* before surgical operations.

Dr. Barnes emphasized the frequent incidence of *Taenia* in human subjects in Siam, stating that *T. saginata* was much more frequently encountered there than *T. solium*. The average incidence of *Taenia* in Siam, according to the speaker, is 4 per cent., and the highest incidence in any one section is 29 per cent. He stated that as many as 14 to 18 specimens of *Taenia* have been found in single individuals. He considers that the symptomatology of taeniasis in man required more careful study. He noted that vomiting of tapeworms following the administration of insufficient doses of anthelmintics is not uncommon and stated that as a result of such vomiting patients may be sick for two weeks following the incident. He also noted that thymol is superior to oil of chenopodium for removing tapeworms. These remarks were discussed by Dr. Stiles.

The eighty-second meeting was held December 20, 1924. Dr. Ransom was elected Vice-President to represent the society on the Board of Managers of the Washington Academy of Science.

Dr. Hall presented the following notes:

The goat as a host of *Paragonimus*.—A collection of thirty-six flukes, was sent December 2, 1924, to the Zoological Division of the Bureau of Animal Industry by Dr. J. S. Jenison with a history to the effect that these flukes were collected from the lungs of a yearling female goat at the National Stock Yards, Illinois. On examination the flukes proved to be a species of *Paragonimus*. The specimens were slightly macerated and no spines could be found on which to base an identification of the flukes as *P. westermani*, *P. ringeri* or *P. kellicotti*, assuming that these are valid species or that they are varieties adapted to different hosts. If all these lung flukes are regarded as

the same species, the flukes from the goat may be called *P. westermanni*. If we accept the validity of the two species other than *P. westermanni*, then since the form from the dog, cat and pig in the United States is the form recognized by some writers as *P. kellicotti*, the flukes from the goat may be regarded as *P. kellicotti*. Pending further information the question of exact identity may be left open. In reply to a request for information as to the origin of the goat, Dr. Jenison states that it was shipped, apparently, from Brooksville, Miss.

So far as known the goat is a new host for *Paragonimus*. It is certainly new for the United States. However, there is an extensive literature on *Paragonimus* in Japanese, and much of it is not available in any form at present, so there is a possibility that reports have been made of lung fluke from the goat in Japan.

A new anthelmintic, tetrachlorethylene, by M. C. Hall and J. E. Shillinger.—Tests of tetrachlorethylene ( $C_2Cl_4$ ) on over 50 dogs show that it has an efficacy against hookworms which is comparable to that of carbon tetrachloride ( $CCl_4$ ) and which may be even slightly greater. It is highly effective in doses at the rate of 0.2 c.c. per kilo, and even 0.1 c.c. per kilo, in removing hookworms. The efficacy falls very slightly when dry magnesium sulphate is also given in bulk equivalent to the bulk tetrachlorethylene, and falls decidedly with the saturated solution of Epsom salts or castor oil simultaneously administered with it. Ordinarily dogs tolerate very large doses, up to 15 c.c. per kilo, but occasional dogs, such as those suffering with distemper, may die following doses at the rate of 0.6 c.c. per kilo, and presumably after even smaller doses in some cases. The symptoms and lesions appear to be similar to those of carbon tetrachloride. The drug appears to be pleasanter to take than carbon tetrachloride. It has a pleasanter taste and odor. One of the writers (M.C.H.) took 1 c.c. and experienced no reaction in the way of warmth at the stomach, headache or dizziness. On retiring 12 hours later there was a marked muscular relaxation, slight cerebral discomfort, with sleep following promptly and marked by a dream of levitation, unusual in the experience of the subject, in which the dreamer could lift both feet 3 to 4 inches off the ground simultaneously without difficulty and maintain the position. A detailed report of the experiments will be published elsewhere and also a note calling the chemical to the attention of physicians and suggesting cautious test under hospital conditions. At present the chemical is two or three times as expensive as carbon tetrachloride, but it might be produced cheaply if there was a market for it and it may have certain advantages in the way of mild effects on patients over carbon tetrachloride.

Dr. Johannsen, naturalist of the Canadian Arctic Expedition, gave an illustrated lecture on the fauna and flora studied during that expedition.

Dr. Stiles and Miss Orleman invited attention to the fact that the generic name *Loxotrema* Kobayashi, 1908, mt. *ovatum*, is being used by various authors in the trematodes. They pointed out that this name is preoccupied. It was used by Gabb, 1868, Nov. 3, American Journal of Conchology, v. 4 (3), p. 147, pl. 14, fig. 21, for a mollusc, mt. *turrita*, California. The trematode genus named *Loxotrema* (homonym) is to be supplanted by *Metagonimus* Katsurada.

Dr. Stiles and Miss Spear reported a case of *Dermatobia hominis* in a man who came from South America and who was admitted to a government hospital in California. The specimens were sent by Dr. Hetrick.

Dr. Chapin reported that the European hedgehog (*Erinaceus europaeus*) in the National Zoological Park is infested with fleas (*Archaeopsylla erinacei*) and expressed the opinion that this species of flea is not likely to parasitize the American hedgehog.

Dr. Cort called attention to a morphological difference between the infective larvae of *Ancylostoma duodenale* and those of *Necator americanus*. In the latter there is a buckling in where the esophagus joins the intestine, producing



a definite space, between the esophagus and the intestine, whereas in *Ancylostoma duodenale* this space is absent. In the discussion of Dr. Cort's note, Dr. Hall called attention to recent work by van Thiel bearing on morphological differentiation of hookworm larvae.

Dr. Blanchard reported what is presumably a protozoon parasite of a salamander. The parasite is ciliated and multiplies by budding and by multiple fission.

Dr. Hegner presented the following notes:

In a South American monkey that had been in this country about three weeks *Giardia* cysts were found in the stools. The cysts disappeared after several weeks. No trophozoites were found in the intestine when the monkey was examined post-mortem.

*Giardia* from cats was compared with *Giardia* from mice, dogs and human beings and was found to be different from the forms in the latter hosts. The name *Giardia felis* is proposed for these parasites from cats. *Giardia* cysts were found in wildcats but no trophozoites were found. The cysts differed in size from those in the domestic cat. *Giardia* trophozoites were found in the intestine of the black-crowned night heron at Cold Springs Harbor, Long Island, N. Y. and in the intestine of the great blue heron at Baltimore.

Miss Cram reported a communication from Dr. Riley in which he reviews the previous reports of *Diocotophyme renale* as follows: Twenty-seven cases reported by him in 1916 from Canada and the United States; general observations of several cases seen by Dr. Luckhardt in dogs used at the University of Chicago, and by Dr. Zeit in those at Northwestern University; seven cases reported by Dr. Hall, and 12 cases by Wislocki. Dr. Riley adds 3 new cases: 2 in the laboratories of the University of Minnesota, 1 in which the specimen was sent in from DeWitt, Arkansas by Prof. W. J. Baerg.

Dr. Riley has also made a study to see what the foundation was for numerous reports in newspapers and elsewhere, of the grouse of Minnesota being killed by a parasitic disease. In every instance where birds had been found dead he found that there was evidence of the death being due to gun shot or to bruises and broken bones resulting from the birds flying up in front of automobiles. Ticks were found on only a small percentage of the birds and *Coccidia* were present only in light infections so that they could not be held accountable for any great number of deaths. Parasitic worms were remarkably scarce. No tapeworms and no flukes were found. A round worm similar to if not identical with *Ascaridia perspicillum* was found in about 35% of the birds studied, but this infestation does not appear a sufficient cause of death. No specimens of *Dispharagus* were found, such as were reported by Dr. Allen from grouse of New York.

In the discussion of Dr. Riley's first note, Dr. Stiles called attention to an unrecorded case of *Diocotophyme* in a dog discovered in Johns Hopkins Hospital several years ago.

Miss Cram presented the following notes:

A new genus, *Cylicostomias*, and notes on other genera of the *cylicostomes* of horses.

Upon further investigation, I have found that I was in error in stating in my recent paper on nematode parasites of the Equidae, in the Journal of Agricultural Research, that the name *Cylicostomum* was available for Railliet's species *Trichonema aegyptiacum*. Railliet has noted that *Cylicostomum* is invalidated and Dr. Stiles concurs in this. Therefore I wish now to propose the name *Cylicostomias*, with type *C. aegyptiaca* (Railliet 1923). The other species in this genus are *Cylicostomias coronata*, *C. labiata*, *C. labiata* var *digitata*, *C. labrata*, *C. ornata* and *C. sagittata*.

In the genus *Cylicobrachytus* I have designated as type *C. prionodes*; other species, *C. brevicapsulatus*. The type species of the other genera may be desig-

nated in accordance with the group names as originally used by Ihle. They are as follows: *Cylicocercus*, type *C. alveatus* (Looss 1900); other species *C. catinatus*, *C. catinatus* var. *literaureus*, *C. goldi*, *C. mettami*, *C. pateratus*, *C. pseudocatinatus*, *C. tridentatus*. *Cylicodontophorus*, type *C. euproctus* (Boulenger 1917); other species, *C. bicoronatus*, *C. ihlei*, *C. ultrajectinus*. *Cylicostephanus*, type *C. calicatus* (Looss 1900); other species, *C. asymmetricus*, *C. barbatus*, *C. hybridus*, *C. longibursatus*, *C. minutus*, *C. poculatus*. *Cylicotoichus*, type *C. montgomeryi* (Boulenger 1920). The type species of *Trichonema* is *T. tetracanthum* (Mehlis 1831) Railliet and Henry 1919; other species, *T. adersi*, *T. auriculatum*, *T. bogoriense*, *T. elongatum*, *T. elongatum* var. *kotlani*, *T. leptostomum*, *T. nassatum*, *T. nassatum* var. *parvum*, *T. radiatum*, and *T. tiramosum*.

*Capillaria meleagris-gallopavo* from a turkey at Bethesda, Md.—No other specimens are present in the helminthological collection of the Bureau of Animal Industry except that in one bottle labeled *Trichosoma* are several worms resembling *C. meleagris-gallopavo*, collected in 1907 from a turkey in Washington, D. C.

*Paramphistomum cervi* from the gullet of cow. This parasite usually occurs in the rumen and reticulum. Specimens were sent in for identification by Dr. Bishopp from Utica, N. Y., with the statement that they were attached to the lining of the gullet.

Miss Cram presented a note by Dr. Kessel. The ingestion of erythrocytes by *Trichomonas hominis* and its occurrence in the pus of an amoebic liver abscess.

BENJAMIN SCHWARTZ, *Secretary*.

## BOOK REVIEW

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PRINCIPES D'HYGIENE ET DE MEDECINE COLONIALES. Edited by  
M. NEVEU-LEMAIRE. Paris: Ancienne Maison Challamel, 1925, 259 pp.,  
133 figs.

Professor Neveu-Lemaire has added another fine work to the series of valuable contributions from his pen. He begins with a discussion of tropical climates and their influence on the unacclimated. Then he takes up the rôle of parasites in tropical pathology, and in a series of eight chapters deals with the various parasitic diseases of the tropics. Following these come chapters on dangerous animals and plants and on the hygienic regime advisable for Europeans in warm countries. The treatment of each topic is necessarily brief in a work of such limited compass but the style is lucid and brilliant, the illustrations numerous and very good and one may safely predict that it will make a lasting impression on the student. One can hardly commend the work too highly as an illuminating and inspiring introduction to the field for the biologist as well as the physician.

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## NOTES

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Meetings of the Council of the American Society of Parasitologists were held February 21 and April 25. Applications for membership were voted on at both these meetings. The total membership of the Society is now 153. The Society has been affiliated with the American Association for the Advancement of Science. It has been decided to hold the first annual meeting in connection with midwinter meetings of the Association in Kansas City. The Council is already at work on the program for this meeting. Those interested should address the Secretary, Dr. W. W. Cort, 310 W. Monument St., Baltimore, Md.

*The Ceylon Journal of Science* has established a new publication for Section D Medical Science and the first number devotes a considerable part of its pages to investigations on hookworm diseases in Colombo.

Professor G. Delamare of Constantinople has written an admirable treatise on Bronchial spirochetosis. The material is concisely tho exhaustively handled and while the major part of the booklet is devoted to clinical data, one finds a good presentation of the morphology, physiology and distribution of the causal organism. The work will surely appeal to a wide range of students.

The International Health Board has published an interesting pamphlet on the use of fish for mosquito control. Various general questions are discussed at the outset, such as the biological method of combating insects, the function of fish, etc. Then fish control in various countries is thoroly reviewed by

geographic areas. Finally the authors consider suitable kinds of fish, their limitations and advantages. The splendid bibliography which closes the treatise will be appreciated and utilized by many.

The Annual Report for 1923 of the Department of Health Malaria Research Unit, Haifa, is a record of valuable work on malaria control done in Palestine. The work was splendidly organized and carried on both an effective educational campaign and most successful practical measures in permanent elimination of breeding places.



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#### ERRATA

On page 130 for *Ampullaria crassa* sp. read *Spix*

On page 163 Center head for *Dioicestus* read *Dioicocestus*